THE

Mariners Magazine,

STOR'D WITH THE FOLLOWING

MATHEMATICAL ARTS:

The Rudiments *of* NAVIGATION *and* GEOMETRY.
The Making and Use of divers MATHEMATICAL INSTRUMENTS *for* Sea *or* Land.
The Doctrine *of* TRIANGLES, Plain *and* Spherical.
The Art *of* NAVIGATION, *by the* Plain-Chart, Mercator's-Chart, *and the* Arch *of a* Great Circle,
The Art *of* SURVEYING, GAUGING, MEASURING, GUNNERY, *and* FIRE-WORKS; *With a* Compendium *of* FORTIFICATION.
The Rudiments *of* ASTRONOMY.
The Art *of* DIALLING.

ALSO
The PENALTIES and FORFEITURES relating to the CUSTOMS, and to NAVIGATION.

With TABLES of *Logarithms*, *Sines* and *Tangents*; Declination of the Sun, Latitude and Longitude; Right Ascension, and Declination of the most Notable *Fixed Stars*; of the Longitude and Latitude of Places; of Meridional Parts, with other Tables necessary in Navigation.

By Capt. SAMUEL STURMY.

Revised, Corrected and Enlarged,
By JOHN COLSON, *Teacher of the* Mathematicks *in* London.

The Fourth Edition, with useful Additions.

LONDON,
Printed for *Richard Mount*, at the Postern on *Tower-Hill*, MDCC.

TO THE

READER.

Courteous Reader,

MAthematical Studies have for these many Years been much neglected, if not contemned; yet have there been so many rare Inventions found, even by Men of our own Nation, that nothing now seems almost possible to be added more. As in other Studies, so we may say in these, *Nil dictum quod non dictum prius*: We at the least must needs acknowledge, That in this we have presented thee with nothing new, nothing that is our own. *Ex integra Græca, integram Comœdiam hodie sum acturus*, saith *Terence*, that most excellent Commedian, in his *Heautontimorumenon*. Translation was his Apology; Transcription, Collection, and Composition ours, This only we have endeavoured, that the first Principles and Foundations of those Studies (which were not to be known until now, but by being acquainted with many Books) might in a due method, and perspicuous manner, be as it were at once presented to thy view.

Qui edifie en publique place, Faict maison trop haut ou trop basse. *Who builds i'th' way where all pass by, Shall make his house too low or high.*

The matter, being Mathematical and Practical Arts of my own Practice, I can the better avouch the ease and truth of them to all ingenious Practitioners, and unto such as have as yet learned nothing but *Arithmetick*.

To that purpose, we have in the first Book laid down such Propositions, as all young Seamen are or should be perfect in, concerning the Compass, and the *Moons* Motion, Instrumentally and Arithmetically; and by it, in the same manner, how to know the Rules of the Ebbing and Flowing of the Sea, with the Rules of time of Flood and High-Water in any Port in the World; with a Discourse of the Practick part of Navigation, in working of a Ship in all Cases and Conditions of Weather at Sea, to the best of my Experience.

And the A B C of Geometry, its Definitions and Geometrical Problems, out of *Euclid* and others, as must be known to such as would know the Nature and Mensuration of Triangles. In the 2d Book we have proceeded to the Descriptions of all the most useful Instruments for Artists and Navigators; as the Scale of Scales, which is a Mathematical Ruler, that resolves all Mathematical Rules whatsoever: And we our selves have fitted Tables and Diagrams in that manner, as we presume has not been done in that plainness, and so easie to be understood, by any Man before. There is the Diagrams and Tables together, both Natural and Artificial; and the Scale, and its making and use follows. As also, The making and use of the Traverse-Scale of Artificial Points and Quarters; The making of the Quadrant and Index, and their ready use in Astronomy and Navigation; and the Protractor; The Projection and use of the *Nocturnal*, and new Tables of the North Star's Declination. And on the back-side are 32 of the most useful Stars in the Heavens for Navigators, and its Use; with Tables of the Longitude and Latitude, Right Ascension and Declination; The Description and use of the Fore-Staff, Sea-Quadrant; as also a new Quadrant and Quadrat, that I use my self at Land and Sea; A Constant Kalendar, joyned with the Tables of the *Sun's* Declination, for Years to come. In the Third Book is shewn, The Nature and Quality of Triangles. Of Sailing by the Plain Sea-Chart, and the uncertainty thereof; and of Navigation by *Mercator*, or *Wright's* Projection, and by the nearest way of Sailing by the Globe, or Arch of a Great Circle; with the making of the True Sea-Chart, Geometrically, Arithmetically, and Instrumentally, as the true way of keeping a Journal at Sea, very easie at once by *Plain*, *Mercator*, or Great-Circle-Sailing, with Tables of Longitude and Latitude of Places round the World, from the Meridian of the *Lizard*, terminating at 180 deg. East and West of that Meridian.

In the Fifth Book is the Art of Surveying of Land by the Azimuth or Amplitude Compass, very easie and useful for Sea-men: The Art of Gauging of all sorts of Vessels, and Measuring of Timber, Stone, and Glass, and Ships, Geometrically, Instrumentally, and Arithmetically; and a most excellent Gunner's Scale, with the easiest way of Gunnery that hath been writ by any: For what Nye hath done by Arithmetick, by the Square and Cube, and their Roots, which is the hardest sort of Arithmetick, by Multiplication, and Division, I have done by the Logarithm Tables, by Addition and Substraction, and likewise Geometrically and Instrumentally. The Scale shews at once, in a moment, the ready Dimensions of twenty sorts of most useful Ordnance, from a Base to a Cannon-Royal, their length, and weight of the Gun, Powder and Shot, and Tables of Shot of Lead, Iron and Stone; with a Table of Right Ranges and Point Blanks; with a Plain Scale and Dialling-Scale, Quadrant and Quadrat, for taking of Heights and Distances; with a Line of Inches and Numbers, for the ready working of all other Proportions of Solids, or otherwise; being a most useful Instrument for all Land and Sea-Gunners: But most especially I do advise all Sea-Gunners to carry one of those most useful Instruments in his Pocket, and by our Directions learn the use perfectly of them. I am ashamed to hear how senselesly many Sea-Gunners will talk of the Art, and know little or nothing therein, but only how to spunge, lade, and fire a Gun at Random, without any Rules of finding the Dispart, thickness of the Metal in all places, and proportion any Charge of Powder thereto, and other Rules which should be known. Herein how many of them are defective? And to supply that defect, I have taken this pains in the Art, to the end to help all such as are ingenious and willing to learn: As also, all manner of Artificial Fire-works and Rockets, with their Figures and Fiery-Arrows, Granadoes, and Pots.

The Sixth Book is the Art of Astronomy, containing the Definition of the Circles of the Sphere, with the manner how to resolve all the most necessary Propositions thereto belonging, by a Line of Chords and Sines, and Chords and Tangents, and half Tangents, Geometrically and by Calculation, by the Logarithm Tables of Artificial Sines and Tangents; And all useful Astronomical Propositions appertaining to the first Motion; and Tables for finding always the *Sun*'s true place; being all of extraordinary use, and made plain to the meanest Capacity.

The Seventh Book is the Art of Dialling by the Gnomonical Scale, with the Diagram and making of the said Scales, with Tables also in the Second Book described; with the Fundamental Diagram of all Scales on the Ruler, as also by Calculation, shewing the making of all sorts of Dials, both within Doors and without, upon any Wall, Ceiling, or Floor, be they never so irregular, wheresoever the direct or reflected Beams of the *Sun* may come, for any Latitude; and how to find the true hour of the Night by the *Moon* and *Stars*; and how to Colour, Gild, and Paint Dials; and how to fasten the Gnomon in Stone or Wood. We have insisted the more upon it, and by our Explanation have endeavoured to make it plain and easie, it being all our own Practice so that nothing may be wanting, which either former Ages or our own (by God's Blessing and their Industry) have afforded to us. We have to the Artificial Canon added Rules to be taken and observed in use of *Gunter's* Canon of Artificial Sines and Tangents, and *Briggs's* his Canon of Logarithm Numbers, as in that Form, and in this Work, we have made use of his Directions in the Astronomical Calculation, and the Demonstration by our own Rules; and of *Norwood's* Advice in Navigation, and by Demonstration our own (the way of our usual Practice at Sea in keeping our Journal) and for the Longitude and Latitude of Places, we have had the best Experience we could procure from others that have been in several Parts of the World, and likewise of our own Observation of several Places in the *West Indies*, and other Parts, together comparing of them with several Tables, formerly made and lately corrected, and fitted for a Meridian of our own Country, and the Principal Cape of this Land, for thy ease; the *Lizard* being the farewel Cape to most Ships that Sail out of the *British* Seas, any way to the South or West, and likewise the first Land made at their return home; and therefore it must needs be very useful for all Northern and Southern Navigators in their Voyages, with great ease and exactness.

It's nothing new, nor does it come by Chance,
That Art is envy'd still by Ignorance.

For the Art of Gauging, I have conferred with Mr. *Sciamred*; and all the Rules that have been laid down in the following Treatise, are most exact and easie to the meanest Capacity

Capacity of ſuch as are skilful in Arithmetick; but with much Labour, Study, Care, and Charge, in the Tryal and Practice of them by our ſelf: which may be conſidered by the Ingenious Practitioners, though much more abuſed by Ignorant *Momus* and his Mates, who make it their buſineſs t› ſcoff, deride, affront, and abuſe all ſuch as are Ingenious, and pretend to have any thing more than themſelves; and you ſhall know them by their railing Diſcourſe of any Ingenious Work or Artiſt. Such for their Malice, Abuſes, and Reviling of thoſe that Study the Honour of their Country to Poſterity, the harmleſs Study of Vertue, and Praiſe-worthy Commendation of all good honeſt-minded Men: I ſay, ſuch *Momuſſes* will have their Reward in another Life, if they give it not over, and repent of it in time. But for all honeſt-minded Men that love Arts and Sciences, Theorical and Practical, God doth give them his Spirit to guide them in all lawful Arts, to the Knowledge thereof, according to their deſire of him.

Others that have either ſpent more time, or made a farther Progreſs in theſe Raviſhing Studies, might (if they would have taken the pains) have haply preſented thee with more in leſs room; but the moſt of this was at firſt Collected for our Private Uſe, and Direction of our three Brothers and Son; but now Publiſhed for the good of others. Nevertheleſs, I am not ignorant, how that never any Man living, in his Writing, could pleaſe the Phanſies of all Men, neither do I expect, to be the firſt. Let every one do as his Genius doth beſt diſpoſe him, take where he pleaſeth, read what he liketh, and leave what he liketh not. For my own part, I have with much Diligence and Induſtry waded through many Ænigmatical Difficulties, and have removed and drawn back the Curtain of Darkneſs from off our Engliſh Horizon, in our Mathematical and Practical Arts following.

Laſtly, I deſire the Judicious Reader, if he chance to meet with any Errors (as ſome may happen in a Work of this Nature) that he would courteouſly amend them, and not with Cavillation ungratefully requite my painful Labours. Haply, if this find Acceptance, it may encourage me to publiſh ſome other thing, which may give much ſatisfaction, and be commodious to my Country-men of *England*.

To the Navigators and Mariners of England.

Brethren,

THE Duties of a Friend, and the Properties of a Flatterer differ ſo greatly, that a Man cannot perform the Office of the one, but he muſt renounce the Practice of the other; and a very Fountain it is, from which many Miſchiefs do ſpring and overflow the wretched Life of Mankind, that the true dealing of Friends is moſt commonly unpleaſant and hateful; but the ſoothing of Flatterers is become plauſible, and much ſet by: In reſemblance they bear many times like ſhew; but in purpoſes they always differ. A true Friend will ſometimes commend and praiſe divers things in his Friend; and ſo will alſo the Flatterer, in thoſe whom he followeth. The one commendeth that which in Judgment he thinketh commendable, to the end that his Friend ſhould ſtill proceed in Actions worthy of Commendations; the other commendeth even thoſe things many times which in Heart he doth deteſt, to the end that he may ſooth up the Humor of the Party. A faithful Friend, what he diſallows in his Judgment of his Friend, he will be earneſt with him to ſee the fault, to the end the Party may amend, and give no advantage to his Enemy. The Flatterer ſometimes, though ſeldom, will alſo diſcommend, but evermore trifling matters; fearing to offend the Party, if he ſhould touch him, counterfeiting ſincere Love (the Badge only of true Friendſhip) and ſo leaveth the Party thus abuſed, to the ſcorn and reproach of the Adverſary, reaping the Reward which he looked for, as the only end of his deſire.

I do not think that there is any Man, that either regardeth God's Glory, or eſteemeth of Humane Society, but holdeth our Art worthy to be numbered with the moſt excellent that are exerciſed among Men: And therefore it is great Reaſon the Practicers of it ſhould be had in greater Reputation than they be now-a-days. Neither is there any other Art wherein God ſheweth his Divine Power ſo manifeſtly, as in ours; permitting unto us certain Rules to work by, and increaſing of them from time to time, growing ſtill onwards towards perfection, as the World doth towards its end; and yet reſerveth ſtill unto himſelf the managing of the whole, that when we have done what we can, according

cording to skill we have already, or may have by any thing that we may learn hereafter, yet always will God make it manifest, that he alone is Lord and Ruler of Sea and Land; That all Storms and Tempests do but fulfil his Will and Pleasure, who oftentimes Administreth many helps beyond all expectation, when the Art of Man utterly faileth; which is lively expressed in *Psal.* 107. where is nothing omitted which is necessary, nor any thing affirmed but that which the continual experience of our daily Dangers do proclaim to be true.

O that we which see his wondrous Works in the Deep, would therefore praise the Lord for his Mercies, and shew forth his Wonders before the Children of Men; that we might once learn, That the fear of the Lord is the beginning of Wisdom. Most undoubtedly then would our Art flourish, our Voyages prosper, and have better success; yea, our selves would be more esteemed and honoured of all Men. Whereas the now Profane Lives, and bruitish behaviour of too too many of our Employ, doth eclipse the Glory of our Profession it self. Besides other manifold Punishments, God striketh some of us with the Spirit of Blindness, as no Men living, of any Trade whatsoever, are to be found so ignorant as many of us are: So senseless are we of our own defects, so little desirous to amend them: Yea, and some of us of the greatest Skill and Practice are so loath to give God his due Glory, that many times labouring to suppress it, we make Shipwrack of our own Credits and Reputations, which otherwise of right might acrew unto us. When we have performed a long Voyage, of great Difficulties, wherein many a time and oft we have been at our Wits end, and know not which way in the World to turn our selves, God delivering us beyond our Expectation, as our Consciences can witness; yet when the danger is once past, and that home we be come, we take it as a blemish of our Estimations, and a great Impeachment to our Credit, to give God the Praise, and yield him Thanks; imagining that would derogate too much from the Admiration which we so greedily hunt after among Men. But let me give you one example of this Ingratitude to God, on a Voyage from the *West Indies*, in the *Society* of *Topsham*, a Ship that I had Command of. It pleased God by a violent Storm at Sea, 500 Leagues from *England*, we lost all our Masts, and our Ship several times like to founder. It pleased God that little Provision we made for Sail, and the mischievous Storm continuing, turned to our good: for the Wind was fair, but the Sea so dangerous and grown, that we could not Scud or Sail, but sometimes, but in good time it brought us safe into the foresaid Harbour of *Topsham*. And in our Distress our Men were very mindful of Prayer, as most in a Storm are; but coming to our desired Port, I desired them to return our Gracious God Thanks, with me, for our great Deliverence: Some were willing, but two refused; whereupon I told them, *That when they were next in Distress, it may be God would refuse them help or deliverance.* And so it fell out; for *William Witheridge* of *Kenton* in *Devonshire*, was drowned at *Bilboa* the next Voyage following; and the other was drowned at *London*. Therefore let me advise all, to have a care not to be ungrateful to God.

We of this Nation are too much given to admire Strangers, and contemn our own Country-men.

There are many Men that perform long Voyages God knoweth how, but not they themselves; yet will swear, crack and boast, That they have done all things according to Art; and tell a Tale to Strangers at home, of such Gulphs and swift Currents, more than ever God made, to shadow their Ignorance, and to rob God of his Praise! But yet for the Navigators and Mariners of *England*, I do hope and verily believe, that divers of them do fear God unfeignedly, and do as much dislike the dissolute Course of the common sort, as any Men can: And I do nothing doubt, although the number of such are too few in our Nation, yet are they more than any Nation in the World can shew besides. However, two things are greatly wish'd by all our well-willers; an increase in us of the true Fear of God, and a careful diligence in us, in things belonging to our Art. Where the Fear of God is not, no Art can serve the turn; for that were to make of Art an Idol. And yet all those that fear God, must take heed they do not tempt God: and therefore ought they to use Art, as the means that God hath ordained for their benefit, and be thankful unto him for it. Farewell.

Yours,

SAMVEL STVRMY.

Courteous Reader,

AT the earnest Intreaty of the Book-sellers concerned in this Treatise, I undertook the Viewing and Reforming of this Magazine, chusing rather to erect a New Fabrick to furnish it with a New Store; but they not consenting, I have Repaired the Old Building, and provided the Magazine partly with Old, partly with New Store; and I have endeavoured to render the Mathematical Arts contained herein as familiar as I could, being only a Corrector, not an Author.

I have added the Doctrine of Spherical Triangles, also somewhat in the Astronomical part, and more in the Dialling, and in the whole as there was need; and something I have omitted which I judged Superfluous, others I have Corrected that were Erroneous.

There are some Errors of the Press, which we must Pardon, the Work being troublesome to the Printer as 'twas tedious to me, and being not material, I have omitted them; And as I undertook this Task for the Advantage of Young Students in the Mathematicks, to which I hope it will be serviceable, and acceptable; to whom I am an obliged Servant for their Instruction and Information in the Mathematicks.

JOHN COLSON.

To his Ingenious and Industrious Friend, Capt. *Samuel Sturmy*.

S *uch Noble Captains Honour well deserve,*
A *s to their utmost, King and Countrey serve;*
M *aking their Skill and Practice freely known*
U *nto all others who will Learning own.*
E *ast, West, North, South, thy Compass will them guide,*
L *est they should wander with each Wind and Tide.*

S *tir up thy Noble Genius, and go on;*
T *hy Book shall live, when thou art dead and gon,*
U *nto thy Glory: and proud Braggards will*
R *epine, they could not like thee shew their Skill.*
M *omus may carp, but from all honest Hearts,*
Y *ou'll Thanks have for your* Magazine of Arts.

S *ome Men, when they this* Magazine *shall spy,*
A *nd note the Author, presently will cry,*
M *any such Captains will undo the Trade,*
U *nlock these Secrets, all are Captains made.*
E *nvy thus, Devil like, would keep Men blind,*
L *et Noble Sons of Art be free and kind.*

S *o well stor'd, Captain, is thy* Magazine,
T *hat 'twill invite all sorts: This Bush of mine*
U *nto thy Wine is needless. All Men shall*
R *eap Profit by thy Labour: and if all*
M *en thus would add their Talents unto thine,*
Y *ou'd soon compleat a famous* Magazine.

Henry Phillippes.

To his Judicious Friend the Author, Capt. SAMUEL STURMY on his MAGAZINE of ARTS.

R*Eader, Survey with an Impartial Eye,*
The Care, *the* Pains, *the* Art, *the* Industry,
And Charge, *at which the Author, long, hath been,*
To Store (with Plenty) this his Magazine;
Or, rather Mart *of* Arts; *where you may buy*
(For little Money) INGENUITY:
And be Partaker of those Arts we call
Sciences Liberal, MATHEMATICAL:
He having taken Pains *on th'* Deep *and* Shore,
Grasping and Grap'ling to increase his Store;
And after all his Toil *and* Pains *(thus spent)*
Gives it his Country for an Ornament.
Ransack this CASCATE *(therefore) where you'll find*
Plenty of Jewels *to adorn the Mind.*

And first, is represented to your Eye
Selected Problems *in* GEOMETRY.

In NAVIGATION *Rules it doth afford,*
Will make Men Seamen e're they go a-board:
And when Embarqued on the Ocean far,
May Steer from th' Artick to th' Antartick *Star;*
And so, with Prudence, may a Voyage make
Over the Oceans Universal Lake:
No Places distance hindring of Commerce,
Having free Traffick through the Universe.

The GEODECIAN, *in this Book, may have*
Rules to Survey his Land, and then his Grave.

VINERIUS *now will find it no hard Task*
To know he hath his Due, and Gauge his Cask.

Here MURIFRAGUS *certain Skill may gain*
To reach his Mark, making no Shot in vain.

And fair URANIA *leads you by the Hand,*
Descrying how the Spheres *to understand;*
Unlocking all the Hidden Treasury,
And Secret Myst'ries *in* ASTRONOMY.

In HOROMETRIA *Skill you may attain,*
To trace Sol'*s Course out on a* Dial Plain.

And the MUNITOR *hither may resort*
For Rules *whereby to* Fabricate *his* Fort.
To Spring *his* Myne, *and also* Sconces *raise*
Against his Foes, *to his Renown and Praise.*

And to the Trader *it will be a* Treasure,
Yielding him Knowledge both in Weights *and* Measure.

With this, and such like beneficial Skill,
Our Author This *his* MAGAZINE *did fill;*
And that for th' Good *and* Benefit *of those*
Who honour Vertue, *and to* Vice *are Foes.*
Consider, then, th' elaborate Pains *he took;*
And thank him as thou profit'st by his BOOK.

Will. Leybourn.

BOOKS of Navigation Printed for and Sold by Richard Mount, *at the ancient Shop at the* Postern *on* Tower-Hill.

THE Mariners Magazine; containing the Art of Navigation at large, *&c.* By Capt. *Sturmy.*
The Coasting Pilot for *England, Holland, France, Flanders, &c.*
The English Pilot for the Channel.
The English Pilot for the Streights.
The English Pilot for the *West-Indies.*
The English Pilot for the *East-Indies.*
Sea-Atlas, containing Charts of the Sea-Coasts of the whole World.
Great Britain's Coasting Pilate, by Captain *Collins.*
The Mariners New Kalendar. By *Nathaniel Colson.*
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The Boatswain's Art; shewing the Art of Rigging of any Ship. By *Henry Bond.*
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Epitomy of Navigation, shewing the Doctrine of Triangles, and all the three Kinds of Sailing; Astronomy and Geography, with useful Tables in Navigation. By *H. Gellibrand.*
Norwood's Epitomy, containing Plain and *Mercator's* Sailing, and useful Tables in Navigation. With large and useful Additions, by *James Atkinson.*
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The use of the double Scale of Proportion in Navigation, *&c.* By *S. Partridge.*
The Seaman's Tutor. By *Peter Perkins.*
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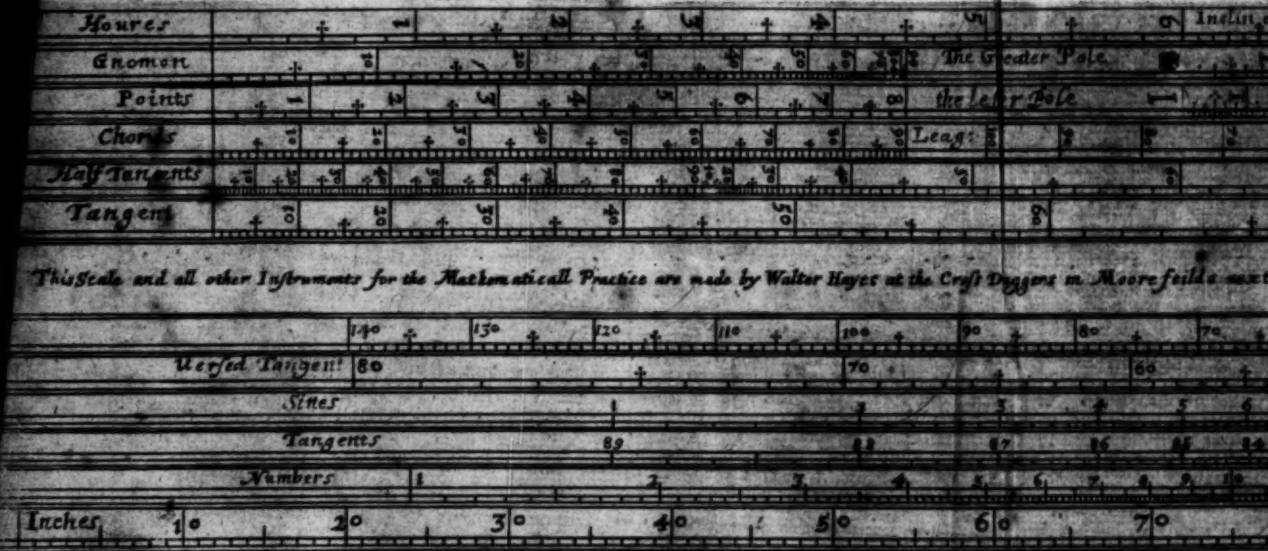
The Rule of Proportion explain'd in Navigation, *&c.* By *Edmond Wingate.*

There are also sold all sorts of Mathematical and Sea-Books in English, Waggoners or Charts for all parts of the World; or Books of any other Subjects, as Divinity, History, Travels, *&c.* and Bibles, or any other Books bound; Journal Books rul'd; all sorts of Paper or Paper-Books; the best Ink, and other Stationary Ware, at Reasonable Rates.

THE

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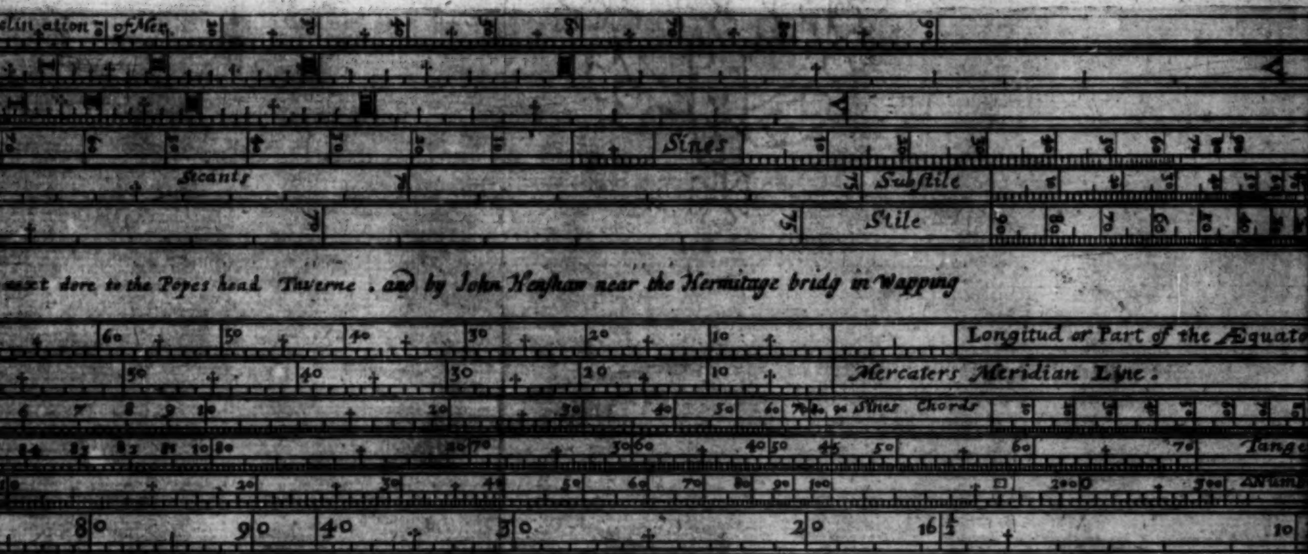
These Naturall and Artificiall Scales are described at large with their Fundamentall Diag
Mathematicall conclusions, with many other Instruments, the makeing and nece

...e SCALE of SCALES

...iagrams in the Second Booke of this Treatise, and their Use exemplified in the Resolution
...necessary use whereof is Demonstrated.

THE MARINERS MAGAZINE, OR THE COMPLEAT NAVIGATOR.

The First Book.

CHAP. I.

The Argument or Description of the Art of Navigation in general.

NAvigation of all Arts and Sciences (setting Divinity aside) hath much reason to have the preheminence; it being of such necessary and publick Concernment; and what Use there is made of it by Sea-men at this present, as Well as hath been in times past, All men know; to whom these Countries are beholden for their good Service, whose Courage hath kept *Great Britain*, Queen and Regent of the Sea, which deserves it well, in respect of the Skill and Valour of her Mariners, and Goodness and Number of her Ships. I wish as long as the Sun and Moon endures, That they may maintain their Courage, and improve their Art, as they ever have, against all Nations that have been *England*'s Enemies; and ever may they crown their Undertakings with everlasting Credit.

The Art of Navigation being such, I think I may be bold to affirm without presumption, This Art is more necessary for the well-being and honour of our Nation, than any other Art or Science Mathematical, which is more carefully kept in the Universities. Look upon Grammar, Rhetorick, and Logick, these are but Introductions to other Arts; Musick is but of little use.

The chief Professions now in the Universities are Physick and Law. Without envy be it spoken. we may as well live as the ancient Romans without Physicians, and as honest Neighbours without Lawyers, better than without skilful Sea-men, which are the chief Importers of our Wealth, and Supporters of our Warfare.

Besides that, of all *Mathematical* Sciences and Arts professed in the Universities, *of this Art of Navigation* is made *the most general and profitable use*: For what can the Scholar make of his Geometry, with all the nice and notional Problems thereof; or of Astronomy, with all his curious Speculations about the Motion of the Planets, without they be applied to some more Mechanical and Practical Arts, as Cosmography, Geography, Surveying Dyalling, Architecture, Military Employments? which shall in some measure (sufficient for the help of Mariners) be shewn in the following Treatise, wherein it will appear; That the Art of Navigation comprehends them all in the use thereof.

And those that will be compleat Sea-Artists, had need to endeavour to have some skill and understanding in most of these Arts, namely, the Theorick and Practick parts; whereby they may be fully informed of the Composition of the Sphere in general; and in particular for the Figure, Number, and Motion made in the Heavens by the highest Moveable, called Primum Mobile, and likewise of the first, second, third, fourth, fifth, sixth, seventh, eighth, and ninth Heavens. It will also inform them how the Elements are disposed, with their quantities and situations, especially in the Composition of the Sphere of the World, which is commonly understood to be the whole Globe of the Heavens, with all that is therein contained; which is divided into two parts, Elementary and Cœlestial. The Elementary hath again four parts, *viz.* The first is the Earth, which together with the Water, as the second, maketh a perfect Round Globe, whereupon we dwell; and therefore the Nature thereof and the Circles which are supposed to be contained in that Sphere, are fit to be known. The next is the Air, comprehending the Earth; and the fourth the Fire, which according to the opinion of Philosophers containeth the space which is between the Air and the Heavens, or Circle of the Moon.

Out of these Elements, which are the beginning of all things that are subject to change, together with the warmth of the Heavens, all things do come forth, and decay, as we see and find upon the Earth, by the continual Change and Motion of the one into the other.

The Cœlestial part (containing within the concavity thereof the Elementary) is transparent and perspicuous, shining, severed and free from all mutability; and is divided into eight Spheres, or concave Globes, which are called Heavens, whereof the greatest doth contain the next unto it; the seven Inferior have in each of them but one Star or Planet only, whereof the first (the next to the Earth) is the Heaven of the Moon; the second of Mercury; the third of Venus; the fourth of the Sun; the fifth of Mars; the sixth of Jupiter; the seventh of Saturn; and the eighth of all the fixed Stars. The Number of these Heavens are known by their Courses round about the Poles of the Zodiack. The Moon runneth through her Heaven by her natural Course from the West to the East in 27 Days 8 hours; Mercury, Venus, and the Sun, their Course in a Year; Mars his Course in two years, Jupiter in 12; and Saturn in 30 years; the eighth Heaven, according to the observation of *Tycho Brahe*, in 25400 years.

These Heavens are all carried together in 24 hours about the Axis of the World by virtue of the Primum Mobile, that is, the first Moveable; by which Motion is caused the Day and Night, and the daily Rising and Setting of the Cœlestial Lights. But more of this in another place, for what I have here made is a Digression. So that no Art is more capacious; and were the Excellency well understood, and put in practice as it might be (as Mr. *Philips* saith in the like case) no Employment would be more honourable and advantageous for the most generous Gentleman and Learned Student, than this of Navigation; thus it was in esteem in the days of Queen *Elizabeth*.

> *When* Drake *and* Candish *sayl'd the World about;*
> *And many Hero's found new Countries out,*
> *To* Britain's *Glory, and their lasting Fame;*
> *Were we like-minded, we might do the same.*

The Practick part of Navigation is properly placed in making and using of Instruments, which is shewn in the Second Book. Yet there is a certain Composition in the Practick, more rare than all the rest, in the Compleat Sea-Artist; and that is the right Words and Phrases used in guiding, governing, and ruling the unparallel'd Fabrick of a gallant Ship, which hath been omitted by most men that have writ of this Art; therefore I shall explain it with my Pen, because I know with proper Phrases how to perform it, not hindring any other (as they not me) to shew truly and lively their Skill in controlling, guiding, and working a Ship, according to all Weathers at Sea; although this be of no use to Sea-men, that have been all their Life-time at Sea, but for Gentlemen on Shore, to read for their Recreation the Words of Command at Sea, may be delightful unto them.

In regard all Arts and Sciences are divided into two principal parts, that is, the Theorick and Practick, and this I take upon me to demonstrate according to my Ability, which will give the most reasonable men satisfaction; and for the unreasonable, I care not a fig for them; for I know it to be impossible for any Man to be a compleat Sea-man, wherein this Knowledge is wanting, they being both Inseperable Companions which always wait upon Perfection. I shall draw out the Description in as small a compass as can be, and hasten to the most material Practice.

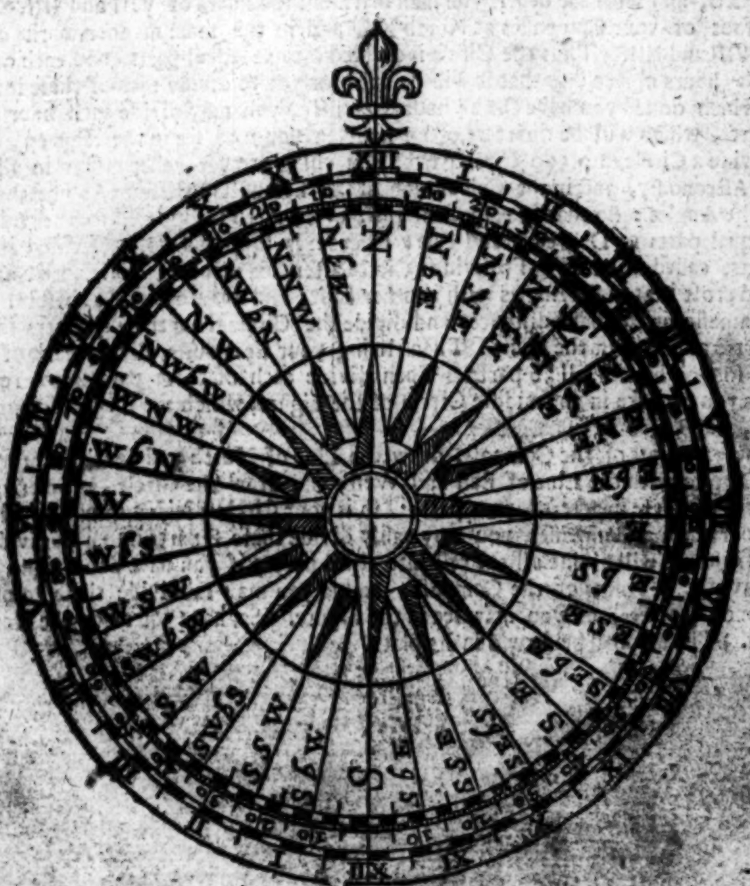
CHAP. II.

Of what is needful first to be known in the Practick Part of Navigation; *of the* Compass, *and how to divide it.*

THE principal Hand-Maids that expert Seamen are furnished with, that their Undertakings may be crowned with everlasting Credit, are these, *viz. Arithmetick, Geometry, Trigonometry,* and *Astronomy.* By the Operation of these loving Sisters, and excellent Arts, as hath been said, *Navigation* is daily practised by expert Seamen: but much abused by hundreds of ignorant Asses, that know nothing what belongs to them, yet

do

do undertake Voyages, to direct a Ship upon the Terrestrial Globe, resting wholly upon favourable Fortune, which hath made some of them famous; but many times disasterous Periods have ended their Undertakings, with the loss of many Mens Goods and Lives; which yet I must confess have and do happen to the most Skilful, but not so often as to them, by a great deal. But to come to the Substance of what is here intended, I would have it to be understood, That he that intendeth the Art of Navigation, hath Arithmetick in readiness. If he want it, he may be instructed by divers Books extant. As for the Trigonometrical and Astronomical Knowledge, so much as is useful for Seamen, will be shewn in the Projection and use of divers Instruments, which will after follow in its due place. In this Treatise we will come to the Sea-Compass, that we may proceed in a regular form: The knowledge of it is the Root of that famous Art we chiefly treat of, and presents it self as the first Principle framed by God, in the Operation and Nature of the Magnet, which being in its Quality beyond our Capacities, yet it is the first thing to be learned and understood, it being the foundation to all the following Conclusions, and is first taught to our Youths and Boys which are intended for Navigators. They are taught first to know the Points on the Chard, by what Names they are called, to say them perfectly forwards and backwards; to know that to every Point of the Compass there is allowed for Time ¾ of an hour, which is 11 Degrees 15 Minutes; and how to number the Hours from the North and South, either Eastward or Westward, readily to answer as soon as demanded: As also to know how the Ship Capes; that is, to know the Point of the Compass that looks straight forwards to the Head of the Ship: As likewise to know upon what Point of the Compass the Wind blows over; that is, if the Wind be at North, it blows over the *Flower-de-Luce* toward the South; and so of the rest. So we teach them to know what Point the Sun is on: As also they learn to set the Moon on the Full and Change days, to know the Tides by, as shall be shewed.



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The Compass [...] our Ships by, is only a Circle of some 8 Inches diameter; and is divided into 32 [...], which have several denominations, as you may see expressed in the Figure. The whole Circle is divided into 360 Degrees, and 24 Hours: The Compass also containts 16 distinct Rhombs or Courses; for each several Course hath two Points of the Compass, by which it is expressed. As for Example; Where there is any place situated South East, in respect of another place, we say the Rhomb or Course that runneth betwixt them, is South-east and North-west; or if it bear South, we call the bearing North and South; or if West, we say East and West. The Compass swings in the Boxes, the Wyers first well touched with a good Load-stone, and the Chard swimming well on the Pin, perpindicular in the middle of the Box; it represents the Horizon. So that when you espy any Island, Rocks, Ships, or Cape-Lands, by looking straight upon the Compass, you shall know upon what Point of the Compass the Object beareth from you. But we will haste to shew the young Practitoners the Sea-Compass, with the 32 Points, expressed by the Letter upon each Line, and also how to make it.

How to divide the Mariners Compass.

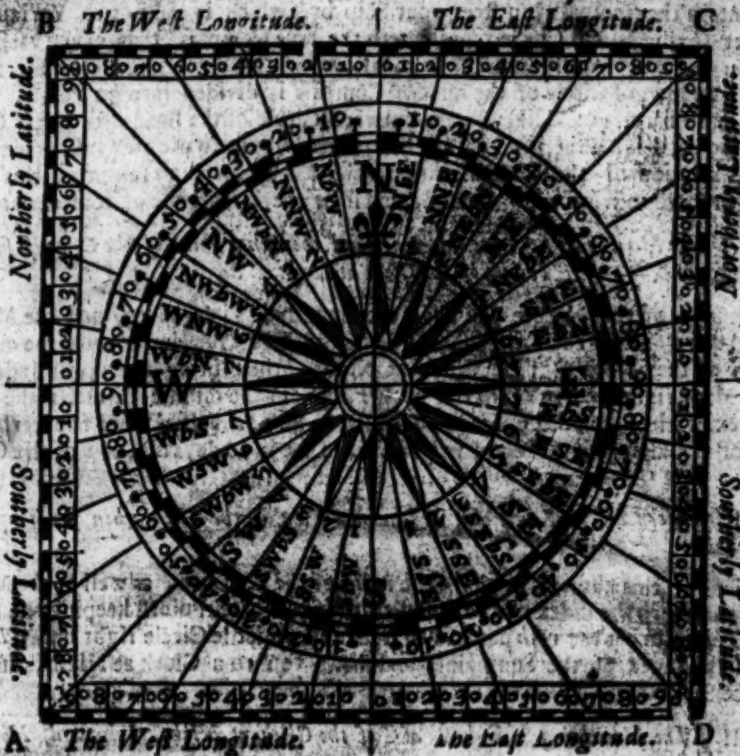
First draw a Line at pleasure, and cross it in the midst with another Line at right Angles; Then in the crossing of these two Lines set one foot of your Compasses, and open the other to what distance you please, and with that distance draw the Circle, which by the cross Lines of East and West, North and South is divided into four Quadrants or equal parts, each of them containing six hours apiece; set VI at East and VI at West, XII at North and XII at South, so you have the four first Divisions of your Figure: Then keeping your Compass at the same distance as you drew the Circle, set one Foot in the crossing of the Line and the Circle at the East VI, with the other make two Marks at II and X. Then set one Foot in the West VI, and on the other side mark out the hours of II and X, as before. Keeping the Compasses still at the same distance, set one foot at South XII, and with the other you shall mark out the hours of VIII and IIII. Then set one foot of your Compasses at North XII, and in the same manner mark out the hours of VIII and IIII. Thus the Circle is divided into 12 equal parts, and each of them contains 2 hours apiece; so that it will be easie for you to divide each of these into two parts; which done, you have the 24 hours. Lastly, you may divide each hour into 4 equal parts, which will be quarters of an hour, as you may see in the Figures.

To divide a Circle into 360 equal parts, is a thing very necessary; for in all Questions in Astronomy, and in the Calculation of all Triangles, these parts are the measure of the Angles: So that in respect of this, every Arch is supposed to be divided into 360 equal parts or Degrees; and every Degree is supposed to be divided into 60 lesser parts, called Minutes. To divide a Circle after this manner, draw a Line at pleasure, and cross it at right Angles with another Line, and draw a Circle as before. Keep your Compasses at the same distance, and divide the Circle from the 4 quarters into 12 equal parts, as before in the hours: Then closing your Compasses, divide each of these into 3; so you have in all 36 parts. Then divide each of these parts into 10 other parts, as you may see in the middle Circle of the Figure, which are Degrees, numbered with 10, 20, 30, &c.

For the 32 Points of the Compass, draw the Line of North and South, and cross it at right Angles with the Line of East and West, and draw the Circle, as before; then divide each of these quarters into 2 parts: so is your Circle divided into 8 equal parts. Then closing your Compasses, you may easily divide these 8 parts into 4; divide one, and that distance will divide all the rest into equal parts, if you have done right. And so you have the 32 Points of the Compass; and so you may subdivide these Points into halves and quarters, as you may see in the Figure. So have you made the Mariner's Compass. The use shall be shew'd in its place.

The

The Figure of the Compass, and the Traverse Quadrat, joyned together.



The Traverse Quadrat sheweth the making of the Traverse Table, in *Book* 4. *Chap.* 3 Of Sayling by the plain Sea-Chart.

Of the Ebbing and Flowing of the Sea, and the Moons Motion.

THE Practitioner in Navigation, is next to learn to know the certain time of the Flowing and Ebbing of the Sea in all Ports, called by Sea-men the shifting of Tides; which is governed by the Moon's Motion, as it is found by Experience.

Wherefore I will first shew the use of a small Instrument, which is here framed, whereby the meanest Capacity (which is void of Arithmetick) shall be able to know the Age of the Moon, with what Flood and Ebb it maketh in all Channels, and in every Port and Creek at High-water; and also what a Clock it is at any time of the Night; and divers other Questions, only by using the Instrument, according as shall be directed.

I shall also shew you, how you may do all these Questions of the Tide Arithmetically: But first by your Instrument. It must be projected according to the following Figure, which you may make of three pieces of Board, well planed, and exactly divided, according as you see it formed in the Figure. The outward Circle, being the biggest Board, hath the 32 Points of the Compass: The inward Circle on the same Board is divided into 24 Hours, being the thickest Board: The second Circle must be divided into 30 equal parts, representing 30 natural days: The innermost Circle of the three hath an Index, and to be turned and applied to either the 30 days, containing the Computation of the Moon betwixt Change and Change, or the 24 hours; as likewise to the Points of the Compass. And so may the other Index be applied either to Time, or the Points of the Compass, which shall be made plain by the following Questions; which will appear delightful and easy. The illeterate man will find it most useful; and he that hath better Knowledge will sometime use the Instrument for variety sake.

A useful Variation Compass.

UPon the upper Circles of the Instrument I have set a most useful Variation Compass; easy to be understood, and as exact as any Instrument whatsoever for that purpose.

pose. You shall have full direction how to use them in the following Discourse, when we come to treat of the Variation of the Compass. But this observe, the middle Compass representeth the Compass you steer your Ship by, which is subject to Variation; but the upper Compass and Circle representeth the true Compass, that never varieth; and by it you may very readily know how to allow for the Variation of the Steering-Compass. The inward Circle of the middle Compass is divided into 32 Points, with their halves and quarters; and likewise the outward Circle of the smaller or upper Compass. 'Tis too hard for Practitioners at first to know how to use this Instrument, to rectify the Variation of the Compass; therefore I shall dwell no longer on this Discourse, but proceed to what was promised, and shew the farther use of it afterward.

PROP. I. *The Moon being 16 Days old, I demand upon what Point of the Compass she will be at 8 of the Clock at Night.*

In all Questions of this Nature you have the Hour and Time given, and the Moons Age, to find the Point of the Compass. To answer these Questions, place the middle Index of *Sol* or the Sun on 8 of the Clock at Night; then bring the upper Index of *Luna* or the Moon right over the *16th* day of her Age, in the middle Circle of the Sun, and the Index of the Moon or upper Circle Points, to *E. b. S.* half a point Southerly, the true Point of the Compass the Moon will be, when she is 16 days old, at 8 of the Clock at Night.

PROP. II. *Moon being 16 days old, I demand, What is the Clock when she is upon the S. E. Point.*

In Questions of this nature, you have the Point of the Compass, as well as the Moons Age: therefore turn the Index of the Moon to the South-East Point, keeping the Index fast to the Point, bring the *16th* day of her Age in the middle Circle right under *Luna's* Index, and the Index of the Sun points and shews you 10 a Clock at Night, that the Moon will be South-East.

PROP. III. *The Moon being S. E. b. S. at 8 of the Clock at Night, I demand, How many days old she is.*

In such like Questions, you must first put the Index of the Moon to the Point of the Compass South-East by South, and the Index of the Sun set to the hour of the Night; then look where the Index of the Moon cuts the Circle of Days, and you shall find it cut the *13th* day of the Moons Age required.

PROP. IV. *The Moon being E. S. E. and the Sun W. N. W. I demand the Moon's Age.*

In all Questions of this nature, observe what you have given; then put the Index of the Moon to the E. S. E. Point, and hold it steady whilst you put the Index of the Sun to West-North-West, and then look where the Index of the Moon cuts in the Circle of Days; and you shall find it cut the *15th* Day of her Age, that is the Day she was at the Full, and answereth the Question desired.

PROP. V. *Moon being 17 Days old, I demand the time of the Day she will be E. N. E.*

In all these sorts of Questions, you must put the Index of the Moon to the East North-east Point, stop it fast there, and turn the Index of the Sun about until the 17th day of her Age is under the Index of the Moon; then look what hour the Index of the Sun is upon, and you will find it 6 a Clock; which answers the time of the day required.

This is worth your Observation, That if the Index points to the Eastward of the North and South, it shews the Morning 12 hours; if it points to the Westward of the North and South, it sheweth the Evening 12 hours. Thus you see how ready the Practitioner in Navigation may have the Use of this Instrument, and by often practising, it may be in a short time so imprinted in his Mind, that as soon as he hath occasion to use it, he will be able to resolve it by Memory, which is an excellent Ornament to a young Mariner. Therefore let so much satisfie for the Use of the Instrument in such like Questions.

PROP. 6. *By the Instrument to find the time of Ebbing and Flowing, in any Port, River, &c.*

Note, You are to observe just at the time of High-Tide, what Point of the Compass the Moon is upon that day which she haugeth in any Port, River or Creek, where you would

would know the Ebbing and Flowing of the Tides, and time of High-Water or Full Sea. This being found, you may know what hour belongeth to that Point of the Compass, by turning the Index of the Moon, as before was shewed. So you may be sure to have the hour always under the Index, on the Change-day, throughout all the Points of the Compass; and so we shall proceed to Examples.

PROP. 7. *The Moon being 16 days old, I demand what a Clock it will be Full-Sea at* Bristol, Start-point, Waterford, *where an E. by S. or W. by N. Moon on the Change-day makes the Full Sea?*

You are to consider the Point of the Compass the Moon is upon in these Ports, when it is Full-Sea on the Change-day (as in all other Ports) which in these Ports is found by observation to be always East-by-South Moon (which is 6 hours 45 minutes) bring the Index of the Moon to the West-by-North Point, staying it there; bring the 16th day of her Age under the Index of the Moon, and the Index of the Sun will point you to 7 of the Clock and half an hour past, the time of Full-Sea in the Morning. If it be the Evening-Tide, bring the Index of *Luna* to the East-by-South, and stay it there, untill you have brought 16 days under the Index of *Luna*, and the Index of *Sol* will point directly upon half an hour after 7 of the Clock at Night, the time of Full-Sea in the aforesaid Ports. So you may know in every other Port in the same manner, if you do as before directed. And take this for a Rule, That the Moon betwixt Change and Full is ever to the Eastwards of the Sun, and riseth by day, still separating it self from the Sun until she be at the Full: Then after the Full, in regard she hath gone more Degrees in her separation than is contained in a Semicircle, she is gotten to the Westward of the Sun (rising by night) and applieth towards the Sun again until the Change-day, which you may see plainly demonstrated by the Instrument.

PROP. 8. *The Moon being 16 days old, I desire to know at what hour it will be Full-Sea at* London, Tinmouth, Amsterdam, *and* Roterdam, *when a S. W. and N E. Moon makes a Full-Sea upon the Change-day.*

It is found by observation, That the S. W. and N. E. Moon makes Full-Sea in all the aforesaid Ports, when the Moon is to the Eastward of the Sun, that is before her, bring the Index of the Moon to the S. W. Point; then turn the 16th day of her Age under the Moons Index, and the Index of the Sun answereth the Question; That it is Full-Sea at all the aforesaid Ports at 3 of the Clock and ½ in the Morning, the Moon being 16 days old.

PROP. 9. *At* Yarmouth, Dover, *and* Harwitch, *where a S. S. E. Moon maketh Full-Sea on the Change-day, the Moon being 9 days old, I demand the time or hour of Full-Sea that day in the aforesaid places.*

Here it hath been found by experience, that a S. S. E. Moon makes Full-Sea on the Change-day, in the aforesaid places; therefore bring the Index of the Moon to the S. S. E. Point, keep it there fast directly on the Point, and bring the Moons Age to cut the edge of the Moons Index, and the Index of the Sun will shew you, that the time of Full-Sea in the aforesaid Ports, will be at 5 a Clock and ¼ in the Morning.

PROP. 10. *At* St. Andrews, Lisbon, *and* St. Lucas, *where a S. W. by S. Moon makes High-Water or Full-Sea on the Change-day; the Moon being 28 days old, I demand the time of Full-Sea that day in these places.*

You have here given you the S. W. by S. Point of the Compass; therefore bring the Index of the Moon, and stay it on that Point, and bring the 28th day of her Age under the edge of the Index of the Moon, and the Index of the Sun will point you out the time of Full-Sea, which is at half an hour past 12 of the Clock at Noon, in the aforesaid places. And so are all Questions of this Nature answered. Now I will conclude the Use of the Instrument for finding the Ebbing and Flowing of the Tide, and proceed to shew you Arithmetically how to find the *Golden Number* or *Prime*, the Epact and Full, Change, and Quarters of the Moon, and how to know her Age for ever; and what Sign and Degree she is in the Zodiack, how long the Moon shineth, and what time of the day or night it is High-Water or Full-Sea in any Port; and also the Moons Motion, as far as it is useful for Mariners.

I. 27

1. *To find the* Golden Number *or* Prime, *according to the* Julian *or* Old *Account.*

YOu may observe this, That the *Prime* or *Golden Number* is a Revolution of 19 years, in which space the Ancient Astronomers were of Opinion, that all the Aspects between the *Sun* and *Moon* did return to the same point of the Zodiack, that they were in 19 years before. To find this useful Number, you must do thus: Always in that year you would know the *Prime Number*, add 1 to the date thereof, and then divide it by 19, and that which remaineth after the Division is the Number required. For Example, In the Year of our Lord 1665, I demand what is the *Prime Number*. Add to the Year of our Lord always 1, which makes 1666; then divide that sum by 19, the remain is the *Prime* or *Golden Number*, as you may see by the Work; so the *Prime* or *Golden Number* for that year is 13. This you see is very easie to do for any other year. Observe, that when you find nothing remaining after the Division, that it is the last year of the *Moons* Revolution, and you may conclude, that 19 is the *Prime* for that year. *Note*, The *Prime* beginneth always in *January*, and the *Epact* in *March*.

(1
~~2~~7
84 (3
~~1666~~ (84
~~199~~
~~1~~

2. *To find the* Epact, *and what it proceedeth from.*

THe *Epact* is a Number that proceedeth from the difference which is made in the space of one whole year, between the *Solar* year and the *Lunar* year. *Note*, The *Solar* year doth contain 365 days, 5 hours, 48 minutes; and the *Lunar* year (allowing 12 Moons, there being 29 days, 12 hours, 44 minutes between Change and Change) doth contain but 354 days, 8 hours, 48 minutes. So that there is almost 11 days difference between the Revolution of the *Sun* and *Moon*, at every years end; which difference makes the *Epact*. Therefore to find the *Epact* for any year, first you must know the *Prime Number* for that year, which we found before for the year 1665 to be 13. Then you must multiply this *Prime Number* 13 by 11 and it will make 143, which divide by 30, and there remaineth of the Division 23, which is the *Epact* for the year required. So I make no question but that you understand how to find the *Prime* and the *Epact* for any year past, present, or to come. Therefore I hold this sufficient to express so easie a thing as this is. I have told you already, that the *Epact* always beginneth in *March*; but I shall make a small Table for those that are unskilful in Arithmetick, for 32 years to come, in the latter end of the Second Book.

13
11 (2
—— (3
13 ~~143~~ (4
13 ~~30~~
——
143

3. *A Rule to find the Change, Full, and Quarters of the Moon.*

ADd unto the *Epact* of the year proposed the Number of the Months from *March*, including the Month of *March*, and substract that sum from 30, the remain sheweth the Day of the Change: But if the *Epact* be above 26, there this Rule faileth a day at the least; but at other times it will be no great difference: Therefore it may serve for the following Conclusions.

For Example, I desire to know the New Moon in *October*, 1665. The *Epact* is 23 the Months from *March* are 8, which added makes 31, thence substracted, leaves 1, which taken from 30, one whole Moon, there remains 29. So that the 29th day of *October* is the day of her Change, or New Moon, which by Calculation it is at 58 min. past 4 in the Morning. Having thus found the time of the New Moon, you may from thence reckon the Age of the Moon, and so find the Quarters, or Full Moon.

Thus the Moons Age is	Days,	Hours,	Min.
At the First Quarter	07	09	11
At the Full Moon	14	18	22
At the Last Quarter	22	03	33
At the whole Moon	29	12	44

4. *How to find the Age of the Moon at any time for ever.*

ADd to the days of the Month you are in, the *Epact*, and as many days more as are Months from *March*, including *March* for one; and if these three Numbers added together exceed 30, take 30 from it as often as you can, and the remain is her Age: But if the Numbers added be under 30, that's her Age: For Example, 1665, the *Epact* is 23, I demand what Age the Moon is the 21st day of *September*? From *March*

to *September* is 7 Months, the *Epact* 23, and the day of the Month is 21; these added together make 51; from which subtract 29, because the Month hath but 30 days in it, and the remain is 22, the Age of the Moon that day. Had it been the 22d of *August*, and added them together, it would have made 51. Then to have taken 30 out, there had remained 21 for the Moons Age the 22d day of *August*.

5. *To find the Sign the Moon is in; with her Motion for every day of her Age.*

A Stronomers divide the Compass of the Heavens into 12 Signs, which they set forth by these Names and Characters; *Aries* ♈, *Taurus* ♉, *Gemini* ♊, *Cancer* ♋, *Leo* ♌, *Virgo* ♍, *Libra* ♎, *Scorpio* ♏, *Sagitarius* ♐, *Capricornus* ♑, *Aquarius* ♒, *Pisces* ♓, which you must be a little acquainted with, and with the place of the Sun in the Zodiack in each of these Signs, which you have as followeth.

First know, That the *Sun* entereth the first Sign ♈ the 10th of *March*, ♉ the 10th of *April*, ♊ the 11th of *May*, ♋ the 11th of *June*, ♌ the 13th of *July*, ♍ the 13th of *August*, ♎ the 13th of *September*, ♏ the 13th of *October*, ♐ the 12th of *November*, ♑ the 11th of *December*, ♒ the 10th of *January*, ♓ the 8th of *February*. This known, the place of the Sun is well enough found by adding for every day past any of these, 1 Deg.

For the *Sun* runs through these 12 Signs but once in a year; the *Moon* in less than a month, *viz.* in 27 days 7 hours 43 min. *Note*, that at every *New Moon* the *Sun* and *Moon* are in one Sign and Degree; but the *Moon* hath a motion of about 13 Degrees every day, as is shewed in this Table. Therefore according to the Age of the *Moon* add the Signs and Degrees of the *Moons* motion, to the place of the *Sun* at the *New Moon*, and so you shall have the Sign and Degree which the *Moon* is in at any time desired.

A Table shewing the Moons Motion according to her Age.

Age.	Motion.		
Days.	S.	D.	M.
1	00	13	11
2	00	26	21
3	01	09	32
4	01	22	42
5	02	05	53
6	02	19	04
7	03	02	14
8	03	15	26
9	03	28	35
10	04	11	46
11	04	24	56
12	05	08	07
13	05	21	18
14	06	04	28
15	06	17	39
16	07	00	49
17	07	14	00
18	07	27	11
19	08	10	21
20	08	23	32
21	09	06	42
22	09	19	53
23	10	03	03
24	10	16	14
25	10	29	25
26	11	12	35
27	11	25	46
28	00	08	56
29	00	22	07
30	01	05	17

Example, A *New Moon* 1665, begins the 26th of *November*, and the *Sun* and *Moon* are both in 14 Degrees of ♐. Now upon the 11th of *December*, the *Moon* being 14 days old, I would know what Sign the *Moon* is in. This Table shews, for the 14th day of the *Moons* motion, you must add 6 S. 4 D. 28 min. to the said 14 Degrees of ♐.

Now counting those 6 Signs upon your Fingers, reckoning the Names of the Signs in order from *Sagitarius*, ♑ 1, ♒ 2, ♓ 3, ♈ 4, ♉ 5, ♊ 6, it falls upon the Sign *Gemini*. Lastly, adding the odd 14 Degrees, and the 4 Deg. of the *Moons* motion together, shews the place of the *Moon* to be in 18 Degrees of *Gemini*.

To know the time of the Moon's Rising, Southing, and Setting.

FOr her Rising (know this) having found the place, or what Sign she is in, seek out in the Kalendar what time the Sun is in this Sign and Degree, and there you shall find the true time of the Sun-Setting, being in that place: add this to the time of the Moon's coming to the South, it shews the time of her Setting; and subtracted from it, shews the time of her Rising.

Thus upon the 11*th* of *December*, as before, the Moon being 14 Days old, and in the 18*th* Degree of *Gemini*, I desire to know the time of the Moon's Rising and Setting.

First multiply 14, the Moon's Age, by 4, divide the Product by 5; in the Quotient will be 11 a Clock, and $\frac{1}{5}$, which is 12 min. that the Moon will be South that Night. Secondly, The Sun is in this Sign and Degree about the 30*th* of *May*, and then sets at 8 a Clock and 10 Minutes past. This subtracted, shews the Rising of the Moon to be at 3 of the Clock 2 Minutes in the Afternoon. The said 8 hours, 10 min. being added, makes 19 hours 22 minutes, which by casting away 12, the remain shews the Moon's Setting to be at 7 of the Clock, and 22 min. past in the Morning, which answers the Question desired; which may serve for ordinary use.

	H.	M.
☾ *So.*	11	12
☉ *Set.*	8	10
☽ *Ris.*	3	02
Added	19	22
☾ *Set.*	7	22

PROP. 1.

PROP. 1. *How to find when it is Full-Sea in any Port, Road, Creek or River.*

I have shew'd you already how to find the Prime, Epact, and Age of the Moon, at any time desired. Now we will proceed to shew you the finding of Full-Sea in any Place; as in manner following.—— *First*, Carefully observe the time of High-water on the Change or Full of the Moon, in that Port or Place where you would know the time of the Full-Sea, or find by the Table what makes a Full-Sea in the said Port. *Secondly*, Consider the Age of the Moon; then by Arithmetick resolve it in this manner: Multiply the Moon's Age by 4, divide the Product by 5, the Quotient shews the Moon's Southing; if any thing remain upon the Division, for every *Unit* you must add 12 min. if it was 4 remaining, it would be 48 min. to be added; then add the hour that it Flows on the Full or Change to it, and the Total is the hour of Full Sea; if it exceed 12, subtract 12 from it, the Remainder is the hour of the day or night of Full-Sea, in any Port, River or Creek. Which I will make plain by some *Examples*, (viz.)

PROP. 2. *The Moon 16 days old, I demand, What a Clock it will be Full-Sea at* Bristol Start-Point, *and* Waterford, *where an E. b. S. and W. b. N. Moon maketh Full-Sea on Change or Full of the Moon.*

Consider here an E. b. S. Moon maketh 6 hours 45 Minutes, and the Age of the Moon is 16 days: Therefore multiply the Age by 4, and it makes 64; divide that by 5, and it is 12, and 4 remaineth, which is 48 min. To it add 6 hours 45 minutes E. b. S. it makes 19 hours 33 minutes. Therefore subtract 12 hours from it, there remaineth 7 a Clock, 33 Minutes, the time of Full-Sea in the Morning at the aforesaid Ports; which you may compare with your Instrument, and find it very well agree.

☾ *Age*		16
		4
		64
5 (4	*h.*	*m.*
64	(12	48
55		
E. b. S.	6	45
Total	19	33
Subtr.	12	00
Full-Sea.	7	33

PROP. 3. *The Moon being 25 days old, I demand, What a Clock it will be Full-Sea at* London, Tinmouth, Amsterdam, *and* Roterdam, *where it flows S. W.*

Consider that at these Places on the Full or Change-days a S. W. Moon maketh Full-Sea, which is 3 hours. Therefore multiply 25, the Moon's Age, by 4, it makes 100. That divide by 5, in the Quotient will be 20, and nothing remain. To it add 3 ho. S. W. and it makes 23 hours. From it subtract 12, and the Remainder shews you, That it will be Full-Sea at all the aforesaid Places, at 11 of the Clock in the Morning. So you will find it agree with your Instrument.

Age ☾		25
		4
		100
0		
100	(20	
55	3	*S.W.*
	23	
	12	
	11	*Full-Sea.*

PROP. 4. *The Moon being 9 days old, I desire to know the hour of Full-Sea at* Quinborough, Southampton, *and* Portsmouth.

Note, That a South-Moon on the Full or Change-day, maketh Full-Sea at these Places. Therefore multiply the Moon's Age by 4, it makes 36; that divide by 5, and the Quotient is 7 of the Clock; and 1 remaineth, which is 12 Minutes, the time of Full-Sea at the aforesaid Places, the Moon's Age being nine days. *Note*, If a North or South Moon makes Full-Sea on the Full or Change-day, there is nothing to be added to the Quotient; but the Quotient is the hour of the day, and the Remainder is the min. as before directed. One *Example* more shall suffice.

		9
		4
		36
(1		
36	(7	12
5		

PROP. 5. *The Moon 5 days old, I demand the time of Full-Sea at* Rochester, Malden, Blacktail, *where S. b. W. Moon is Full-Sea.*

Here you may note, That on the Full or Change-day at these Places it flows S. b. W. which is but one Point from the South, being but ¾ of an hour, or 45 min. (And it had been all one if it had been North-by-East.) Multiply by 4, divide by 5, and the Quotient will be 4; to it add 45 min. S. b. W. shews you it will be Full-Sea at the aforesaid Places at 4 a Clock and 45 min. in the Morning. By this time I hope I have made the Practitioner able to know the time of Full-Sea in any Port, by Instrument and Arithmetick: I will leave him a small Table for his use.

Rye,

	H.	M.
Rye, Winchelsey, Calshot, a. *S. b. E. Moon.*	11	15
Rochester, Malden, Blacktail, S. b. W.	0	45
Yarmouth, Dover, Harwich, S. S. E.	10	30
Gravesend, Downs, Blacknise, Silly, S. S. W.	1	30
Needles, Orford, South and North *Foreland, S. E. b. S.*	9	45
Dundee, St. Andrews, Lisbon, St. Lucas, S. W. b. S.	2	15
Pool, Isle of *Man, Dunbar, Diep, S. E.*	9	00
London, Tinmouth, Amsterdam, Roterdam, S. W.	3	00
Portland, Hartflew, Dublin, S. b. W.	8	15
Barwick, Flushing, Hamborough, S. W. b. W.	3	45
Milford, Bridge-water, Lands-end, E. S. E.	7	30
Baltimore, Corke, Severn, Calice, W. S. W.	4	30
Bristol, Start-point, Waterford, E. b. S.	6	45
Falmouth, Humber, Newcastle, W. b. S.	5	15
Plimouth, Hull, Lyn, St. Davids, W. & E.	6	00
Quinborough, Southampton, Portsmouth, N. & S.	0	00

Add any two Numbers together of the foregoing Table, and they shall be 12 hours; except the two last, *N. S.* and *E. W.* And what hath been said from the South, either Eastward or Westward, the same answereth to the North, either Westward or Eastward And so much for the Tides. But we will know the Moon's Motion, and the Proportion between Tide and Tide.

PROP. 6. *The Motion of the Moon, and the Proportion of Time betwixt Tide and Tide.*

After all this, I will shew you in brief the Motion of the Moon, and the reason of the difference between Tide and Tide.

You must note; the Motion of the Moon is twofold, First, A Motion, which is from East to West, caused by the diurnal swiftness of the *Primum Mobile.* Secondly, Her own Motion in the Zodick from West to East, which the Moon performeth in 27 days, 8 hours, 8 minutes; in which space she returns to the same point of the Zodiack from whence she departed. But to come to the same Point where she was in Conjunction with the Sun last (by reason the Sun's Motion every day is East, 1 Degree) the Moon must move longer 2 days, 4 ho. 36. min. more than her natural Motion, before she can overtake the Sun, to come into Conjunction with him; so that betwixt Change and Change is 29 days, 12 hours, 44 minutes, by my account The Mariner always allows just 30 days between the Changes, by reason he will not be troubled with small Fractions of Time, in his Accounts of Tides, which breedeth no great error: Reason therefore must needs shew me this, That I must allow, according to that Proportion, the Moon in every 24 hours to depart from the Sun 12 Degree, (which is 48 min. of time.) Now if the Moon move in 24 hours, 48 min. then in 12 hours she must move 24 min. and in 6 hours, 12 min. and by this proportion each hour she moveth 2 min. and so the Tides differ as the time differs.

I will add one old approved Experience for the Mariners use, though it is impertinent in this place, that is, To cut Hair in the New of the Moon; cutting, shaving, clipping in the Wane, causeth baldness. So I hope I have satisfied the Learner concerning the Moon.

CHAP. III.

The Practick Part of Navigation, in working of a Ship in all Weathers at Sea.

WE have been shewing the Practitioner all this while, the Course and Motion of the Moon, and so by it to know how to find the Tides, or time of Highwater, in any Port, Road, Harbour, or Creek, Instrumentally and Arithmetically. The next thing to be observed by a Learner, is the Words of Command, with readiness to answer and obey, which is the most excellent Ornament that can be in a Compleat Navigator, or Mariner. And as Captains exercise their Men on Shore, that their Soldiers may understand the Postures of War, and to execute it, when the Word of Command is given by their Commander: in like manner are Sea men brought up in Practical Knowledge of Navigation at Sea in working a Ship in all Weathers. Although the Rules [illegible] of little benefit

benefit to him, that hath been brought up all his Life-time at Sea; and less to those that be altogether ignorant in Marine Affairs: But that the Practick may be delivered in proper Sea-Phrases, according to each several Material that belongs to a Ship compleatly rigg'd, with the Use of the several Ropes in working and trimming of Sails at Sea on all Occasions, cannot be denied by those that know these things perfectly: Therefore it is impossible for any Man to be a Compleat Mariner or Navigator, without he hath attained to the true Knowledge of Theorick and Practick, being both Sisters and inseparable Companions, that makes them perfect Navigators.

And to explain my self, that I may prevent the Censures of all such that will be curious, inquiring whether I am not lame, or incapable of that, and like themselves appear imperfect; I may speak it with trouble to my self, and shame to others, That there was never more lame and decrepit Fellows preferred by Favour and Fortune, as also by Kindred, Let a man go aboard the best Ship at Sea, and it will be very rare to find Ignorance out of the Officers Cabines, and commonly able Mariners and more sufficient men before the Mast, who are forced to hawl a Bowline, through the aversenes of their Fates, which is great pity. I should be glad to live to see a more equaller Ballance among Sea-men, and their Imployers, to further the industrious, and encourage the deserving Men; for if this partiality should continue long, it is to be feared, in some short time, the Compleat Mariner will be hardly found aboard any Ship, to the great disparagement of our English Nation, which hath from time to time so long deservedly had the Superiority over all other parts of the World, for breeding the most famous Navigators, the Hollander to his Loss knows it right well, that there is none like English for Courage at Sea; but that many of them out strip us in the Art of Navigation, which proceeds from the former unequal Ballance, which makes our expert Sailors, to seek, if Fortune will be favourable amongst the Dutch; or else they had not at this day been High and Mighty, and in such a flourishing Condition as now they are. Therefore I hope to see and hear, That the English Mariner will make better use of swift stealing Time, that he may redeem what is lost, and attain to such perfection, as that he may Parallel his Art with his Valour and Courage; And that Imployers will use more Equity, in placing deserving men according to their merit. I shall not draw out my digression to any longer discourse; for I know my plain Rhetorick will not relish in some mens ears, though it may in others: Therefore I shall draw to a conclusion, desiring that no man will censure me, before he knows what is in me, or is able to mend this. For some there are, will say, being a little touched (as the common saying is) that if they had me at Sea, they would put me to seek all my prescribed Rules; but I would have such to know, That when I am at Sea, I shall work the Ship in all Assays as well as ever they did, and can as often as I shall be called thereunto, after this manner, (viz.)

PROP. I. *The Wind is fair.*

The Wind is fair, though but little; it comes well, as if it would stand; therefore up a hand and loose fore Top-sail in the Top, that the Ships may see we will Sail; bring the Cable to the Capston, heave up your Anchor, loose your Four-sail in the Brailes; put abroad our Colours, loose the Mizen in the Brailes. Is all our men on board? Those that be on Shore may have a Tow, and be blest with a Ruther; for we will stay for no man. Come, my Hearts, heave up your Anchor that we may have a good Prize. Come, Who says Amen? One and all. Oh brave Hearts, the Anchor is a Peak; heave out Fore-top-sail, heave out Main-top-sail, hawl home the Topsail Sheets. The Anchor is away, let fall your Fore-sail, hoist up your Fore-top-sail, hoist up your Main-top-sail; up and loose the Main-sail, and set him; loose Sprit-sail, and Sprit-sail Top-sail. A brave Gale. Bring the fore-Tack to the Cat-head, and trim your Sails quartering; hoise up our small Sails, heave out the Mizen-top-sail and set him. Now we are clear, and the Wind like to stand; hoist in our Boats before it is too much Sea, aboard Main-tack, aboard Fore-tack, a Lee the Helmn handsomly, and bring her too easily, that she may not stay. Brace the Fore-sail and Fore-top-sail to the Mast, and hawle up the Lee-Bowlines, that the Ship may not stay; pass Ropes for the Boats on the Lee-side, and be ready to clap on your Tackles, and hoist them in; stow them fast. Let go the Lee-Bowlines, of Fore-sail, and Weather-Braces. Right your Helmne, hale aft the Fore-sheet, trim the Sails quartering, as before: Loose Sprit-sail, and hale aft the Sheets; and hoise up the Sprit-sail-top-sail, and other small Sails, Set the Mainstay-sail, and Fore-top-sail-stay-sail, and Mizen-stay-sail, and Main-top-sail-stay-sail, and lace on your Bonnets, that we may make the most of our way to our Station. Clear your Ropes. Come, get up our steering Sails. The Lee steering Sails of Main sail, and

and Main-top-sail, Fore-sail and Foretop sail only; for they will sit fairest, and draw most. I have on purpose omitted several Words, by reason I would not trouble the Reader with such indifferent things as are conceived by all Mariners to be done; as Conning the Ship, Bracing, Veering, and Haleing aft, Hoisting, Looring, and the like: but it is to be supposed that all this is done. Thus your have a brave Ship under all her Sails and Canvas, in her swiftest way of Sailing upon the Sea. Now let us have her right before the Wind.

Right afore the Wind, and a fresh Gale.

The Wind is vered right aft, take in your Fore and Fore-top-sail steering-sail, and Fore-top-sail, and Main and Main-top-sail stay-sails; for they are becalmed by the After-sails, and will only beat out. The Wind blows a fresh Gale, round aft the Main-sheet, and Fore-sheets, square your Yards, take in your Main and Main-top-sail, Steering-sails. Unlace your Bonnets. Take in your Main and Fore-top-gallant-sails; in Sprit-sail, and Mizen-top-sail, let go the Sheets, hale home your Clew-lines, cast off Top-gallant-bowlines. Thus you have all the small Sails in, and furled, when it blows too hard to bear them.

The Wind vereth forward, and scanteth.

The Wind scanteth, vere out some of your Fore and Main-Sheets, and Sprit-sheets, and let go your Weather-braces; tope your Sprit-sail-yard. The Wind still vereth forward; get aboard the Fore and Main-tack; cast off your Weather-sheets and Braces: The Sails are in the Wind, hawl off Main and Fore-sheets; the Wind is sharp, hawl forward the main Bowline and fore Bowline, and haul up the Main-top-sail and Fore-top-sail Bowline, and set in your Lee-braces, and keep her as near as she will lie. Thus have you all the Sails trimm'd sharp, and by a Wind.

The Wind blows Frisking.

The Wind blows hard; settle your Fore and Main-top-sails two thirds of the Mast down. It is more Wind, come, hawl down both Top-sails close. Come, stand by, take in your Top-sails: Let go the Top sail Bowlines, and Lee-braces; let go the Lee-sheets, set in your Weather-braces, spill the Sails, hawl home the Top-sail Clew-lines, square the Yard. Now the Top-sails are furled, and you have the Ship in all her low Sails, or Courses.

It bloweth a Storm.

It is like to over blow; Take in your Sprit-sail, stand by to hand the Fore-sail. Cast off the Top-sail Sheets, Clewgarnets, Leechlines, Buntlines; stand by the Sheet, and brace; lowr the Yard and furl the Sail; here is like to be very much Wind. See that your main Hallyards be clear, and all the rest of your Geer clear and cast off. (It is all clear.) Lowr the Main-yard, hawl down upon your down-hawl; now the Yard is down, hawl up the Clew-garnets, Lifts, Leachlines, and Buntlines, and furl the Sail fast, and fasten the Yards, that they may not traverse and gall. Thus have you the Ship a trije under a Mizen.

A very hollow grown Sea.

We make foul weather, look the Guns be all fast, come hand the Mizen. The Ship lies very broad off; it is better spooning before the Sea, then trying or hulling; go reef the Fore-sail and set him; hawl aft the Fore-sheet; the Helmn is hard a Weather, mind at Helmn what is said to you carefully. The Ship wears bravely steady, she is before it; belay the fore doon hall, it is done. The sail is split; go hawl down the Yard, and get the Sail into the Ship, and unbind all things clear of it. Starboard; hard up, right your Helmne, Port, Port hard, more hands, he cannot put up the Helmne. *A very fierce Storm.* The Sea breaks strange and dangerous; stand by to hawl off upon the Lanniard of the Whipstaff, and help the Man at Helmne, and mind what is said to you. Shall we get down our Top-masts? No, let all stand. She scuds before the Sea very well; the Top-mast being aloft the Ship is the wholsomest, and maketh better way through the Sea, seeing we have Sea-room. Thus you see the Ship handled in fair Weather and foul, by and large. Now let us see how we can turn to Windward.

The Storm is over, let us turn to Windward.

The Storm is over, set Fore-sail and Main-sail; bring our Ship too; set the Mizen, the

Main-top-sail, and Fore-top-sail. Our Course is E. S. E. the Wind is at South: Get the Star-board Tacks aboard, cast off our Weather-braces and Lifts; set in the Lee-braces, and hawl forward by the Weather-bowlines, and hawl them taught and belay them, and hawl over the Mizen-tack to Windward; keep her full, and by as near as she will lie. *How Wind you? East.* A quade Wind: No near, hard, no near: The Wind vereth to the Eastward still. *How Wind you?* N. E. hard, no near. The Wind is right in our Teeth; no near still. *How Wind you?* N. W. b. N. The Wind will be Northerly, make ready to go about; we shall lye our Course the other way, no near, give the Ship way, that she may stay: Ready, ready, a-lee the Helm, let go Fore-top Bow-line, vere out the Fore-sheet, cast off the Lee-braces of your Fore-sail and Fore-top-sail, brace in upon your Weather-braces. The Fore-sails is a back-stays, hawl Main-sail, hawl, let rise the Main-tack; cast off your Larboard-braces; let go Main Bow-line, and Main-top-sail-bow-line; brace about the Yard, hawl forward by the Larboard Bow-Lines; get the Main-tack close down in the Chess-tree: The sheet is close aft; hawl off all; hawl; get to Fore-tack, let go fore-bow-line, and fore-top-sail Bow-line; hawl aft the Fore-sheet, hawl taught the Main-bow-line, and Main-top-sail-bow-line; shift the Mizen-tack, hawl taught fore-bow line, and fore-top-sail bow-line; set in the Lee-braces fore and aft, keep her as near as she will lie. ——No near, *How Wind you?* N. N. E. thus, ware no more; no near, keep her full. The Wind is at N. N. E. thus, ware no more. (*How Wind you?*) E. N. E. The Wind is at N. keep her away her Course E.S.E. Cast off the Lee-braces and Weather-bow-lines, and set in your Weather-braces. Vere out the Main-sheet, and fore-sheet, loose the sprit-sail, and Sprit-sail-top-sail, and Mizen-top-sail, and Top-gallant-sails; hoist them up, the Wind veres aft still; let rise the Fore-tack: the Wind's quartering, hawl aft the Fore-sheet, bring it down to the Cat-head with a Pass-a-ree; steddy in your Weather-braces; the Wind stands. Thus you have the Ship as at first, steering under all her Canvas, quarter Wind: she hath been wrought in all manner of Weather, and all sorts of Winds. Therefore we will draw to a conclusion with a Man of War in Chase, and taking of her Prize, and so leave this Practick Part to your Censure.

The Man of War in her Station.

Now we are in our Station, and a good Latitude, hand your Top-sails, and furl your Main-sail and Fore-sail, and brail up the Mizen, and let her lie at Hull, until fortune appear within our Horizon. Up aloft to the Top-mast-head, and look abroad, young Men; look well to the Westward, if you can see any Ships that have been nipt with the last Easterly Winds. *A Sail, A Sail.* Where? fair by us. How stands she? To the Eastward, and is two Points upon her Weather-bow, and hath her Larboard-tacks aboard. O then she lies close by a Wind; we see her upon the Decks plainly. A good Man to Helmn. Up young Men, and loose the fore-sail, main-sail, and mizen. Get the Larboard-tacks aboard; heave out the main Top-sail, fore Top sail, and loose the Spritsail. Keep her as near as she will lie, hawl aft the Sheets, and hawl up your Bow-lines taught. Do you see your Chase? Yea. *How Wind you?* E. N. E. Then the Wind is at N. hoist up your Top-sails as high as you can; heave out Sprit sail-top-sail, and Mizen Top-sail; hawl home the Sheets, and hoist them up: A young man loose the Main-top-gallant-sail, and fore-top-gallant-sail; hawl home the Sheets, and hoist them up; hoist up Main-stay-sail, and Mizen-stay-sail, and loose the Main-top-sail, and fore-top-sail-stay-sails, and set them. It blows a brave chasing Gale; the Ship makes brave way through the Sea, we raise her apace; if she keep her Course, we shall be up with her in three Glasses. No near, keep the Chase open with the Litch of the Fore-sail. So, thus, keep her thus. Come aft all hands, the Ship will steer the better when you sit all quiet, by her small Sails; for she is too much by the Head. The Chase is a lusty brave Ship. So much the better, she hath the more Goods in her Hold. The Ship hath a great many Guns, it may be she's a Privateer. ——*Port*, the Chase is about, come fetch her Wake, and we will be about after her. We Sail far better than she; we have her Wake, a-lee the Helm, vere out fore-sheet. Every man stand handsomly to his business, and mind the Bowlines and Braces, Tacks and Sheets; hawl Mainsail, hawl. Let go Main-bow-line, Top-bow-line, Top-gallant-bow-line; hawl off all, hawl, shifts the Helm; bring her too, hawl the Main-sheet and fore-sheet close aft. Set in the Lee-braces, hawl taught the Bow-lines. The Chase keeps close upon a Wind; keep her open under our Lee. *Gunner*, see that you have all things in readiness, and that the

Guns

Guns be clear; and that nothing pester our Decks. ——Down with all Hammocks and Cabins that may hinder and hurt us. Gunner, is all our Geer ready? Is there store of Cartrages ready fill'd, all manner of Shot at the Main-mast? Is there Rammers, Sponges, Ladles, Priming-irons, and Horns, Lintstocks, Wads, and Water at their several quarters sufficient for them? be sure that none of our Guns be cloy'd; and when we are in fight, be sure to load our Guns with Cross-bar and Langrel. Always observe to give fire when the Word is given. See that there be half Pikes and Javelins in a readiness, and all our small Shot well furnished, and all their Bandaleers fill'd with Powder, and Shot in their Pouches. See that our Murtherers and Stock-fowlers have their Chambers fill'd with good Powder, and Bags of small Shot to load them, that if we should be laid aboard, we might clear our Decks. Starboard, the Chase pays away more room, Starboard hard; vere out some of the Main-sheet and fore-sheet; cast off the Larboard-braces, steddy, keep her thus: Well steer'd; the Chase goes away room, her Sheets are both aft, she is right before the Wind: Starboard hard; let rise Main-tack, let rise fore-tack; hawl aft Main-sheet, hawl aft fore-sheet. We have a Stern-chase, but we shall be up with her presently, for we fetch upon her hand going. The Chase hawls up his Main-sail and furls it; she puts aboard her Wast-cloaths; she will fight us. Come up young men, and furl our Main-sail; sling our Main-yard, with the Chains in the Main-top; sling our fore-yard, put aboard our Wast-clothes; he will fight us before the Wind; I see she is full of Men; it is a hot Ship, but deep and foul. Come chearly my Hearts, it is a Prize worth fighting for; the Chase takes in her small Sails: up aloft and take in our Top-gallant-sails, Sprit-sail-top-sails, Mizen-top-sail, and furl the Sprit-sail, and get the Yard alongst under the Bowsprit. She puts abroad her Colours, it is Red, White, and Blew; they are Dutch Colours, no force; Boy, up and put abroad St. *George*'s Colours in our Main-top; step aft a hand, and put abroad our Ancient; call all hands aloft, come up aloft all hands. They are all up Captain.

Gentlemen, *We are here employed and maintained by His Majesty King* WILLIAM *and our Country, to do our Endeavours to keep this Coast from Pyracy and Robbers, and His Majesty's Enemies; and it is our Fortune to meet this Ship at this time: Therefore I desire you in His Majesty's Name, and for the sake of our Country, and the Honour of our English Nation, and our selves, for every Man to behave himself courageous like Englishmen; and not to have the least shew of a Coward: but to observe the words of Command, and do his utmost endeavour: Into God's Hands we commit our Cause, and our selves. So every Man to his Quarters, and shew his Courage, and God be with you.*

She settles her Top-sails, we are within shot; let all our Guns be loose in the Tackles; and the Ports all knockt open, that we may be ready to run out our Guns when the Word is given. Up noise of Trumpets and hail our Prize; she answereth again with her Trumpets: Hold fast Gunner, do not fire till we hail them with our Voices. Port, Edge towards him, he fires his Broad-side upon us. What cheat my Hearts? Is all well betwixt Decks? Yea, Yea, only he rak'd us through and through. No force, it is his turn next; but give not Fire until we are within Pistolshot. Port, edge towards him. He plies his Small-shot; hold fast Gunner. Port, right your Helm. We will run up his Side. Starboard a little; Give Fire, Gunner. That was well done. This Broad-side hath made their Deck thin, but the Small-shot at first did gaul us. Clap in some Case-shot in the Guns you are now a loading. Brace too the Fore-top-sail, that we may not shoot a-head: He lies broad off to the Southward to bring his other Broad-side to bear upon us. Starboard hard. Get to Larboard Fore tack; trim your Top-sail; run out your Larboard Guns. He fires his Starboard Broad-side upon us, he pours in his Small-shot. Starboard, give not fire until he fall off, that the Prize may receive our full Broad-side. Steady: Port a little; give Fire, Gunner; His Fore-mast is by the board. This last Broad-side hath done great Execution. Cheerly my Mates, the day will be ours; He is shot a-head; He bears up before the Wind to stop his Leaks: Keep her thus; Well Steered. Port, Port hard; Bear up before the Wind, that we may give him our Star-board Broad-side. Gunner, Is there great store of Case-shot and Langrel in our Guns? Yea, Yea. Port, make ready to Board him; Have your Lashers clear, and able men with them. Edge towards him when you give Fire: Bring your Guns to bear amongst his Men with the Case-shot. Well Steered, we are close on board. Give Fire, Starboard, Well done Gunner: They lie Heads and Points aboard the Chase. Come, Aboard him bravely; Enter, Enter. Are you lached fast? Yea, Yea. We will have him before we go here-hence. Cut up the Decks; Ply your Hand

Hand-Granadoes and Stink-Pots. He cries out Quarter; Quarter for our Lives, and we will yield up Ship and Goods. Good Quarter is granted, provided you will lay down all your Arms, open the Hatches, hawl down all your Sails and furl them. Loose the Lachings, we will sheer off our Ship, and hoist out our Shallop, If you offer to make any Sail, expect no Quarter for your Lives. Go with the Shallop, and send aboard the Captain, Lieutenant, and Master and Mates, with as many more as the Shallop will carry. So we will leave the Man of War to his Prize, and to secure his Prisoners. And now I have shewn you thus much of the Practick part of Navigation, in which you may perceive that I have wrought the Ship in all Essays, in Words and proper Sea-Phrases; and if I were at Sea, I should perform it both in Word and Deed: Therefore I leave it all to your Judicious Censures. And so I will conclude with *Ovid*, when he sailed in the *Ionian* Streights.

Nothing but Waves we view in Sea where Ships do float,
And Dangers lie, huge Whales, and all Fish play:
Above our Heads, Heaven's Star-embroidered Coat,
Whose Vault contains two Eyes, for Night and Day;
Far from the Main, or any Marine Coast,
'Twixt Borean *Blasts, and Billows, we are tost.*

If Ovid *in that streight* Ionian *Deep*
Was tost so hard, much more are we on Seas
Of larger Bounds, where Staff and Compass keep
Their strict observance: Yet in this unease
Of tacking Boards, we so the way make short,
That still our Course draws nearer to our Port.

Between the Stream and silver-spangled Skie
We rolling climb, then hurling fall beneath;
Our way is Serpent-like, in Meads which lie,
That bows like Grass, but never makes a Path:
But fitter, like young Maids and Youths together,
Run here and there, all where, and none knew whether.

Our way we know, and yet unknown to other;
And whilst misknown to us, before we dive.
The Hand and Compass that governs the Ruther
Do often erre, although the Pilots strive
With Chart and Compass, yet our Reck'nings fall
Too narrow, short, too high, too wide, too small.

To discon this, remark when we set Land,
Some this, some that do guess, this Hill that Cape.
For some hours our Skill in suspence stand,
Terming this Shore, that Head land Points the Map;
Which when mistook, this forg'd Excuse goes clear,
O such and such a Land it first did 'pear.

In all which strife stress'd Sailors *have the pain,*
By drudging, pulling, hawling, standing to it
In Cold and Rain, both dry and wet, they strain
Themselves, and toyl; none else but they must do it.
Both Prow *and* Poop *do answer to the* Helm;
The Steersman *sings, no Grief his Joy can whelm.*

By Night our Watch we set, by Day our Sight,
And furl our Sails; If Pirates *do appear,*
We rest resolv'd; 'Tis Force make Cowards fight,
Though none more dare, than they that have most fear.
It's Courage *makes us rash, and* Wisdom *cold;*
Yet Wise men stout, and strong, grow Lion-bold.

The Wise-man knows his Wisdom *how to use,*
Th' Artificer, what Art *'tis best to chuse.*
'Tis a true Saying, and approved long,
The Wise-man *is more worthy than the Strong.*
The Field he tills, the City he can guide,
And for the Ships *in* Tempests *will provide.*

CHAP.

CHAP. IV. Of GEOMETRY.

Geometrical Definitions.

ARTS, saith *Arnobius*, are not together with our Minds sent out of Heaven; but all are found out on the Earth, and are in process of time sought and fairly forged by a continual Meditation. Our Minds perceiving some Things to happen well, while it doth imitate, attempt, and try, while it doth reform, and change, hath out of these some Science or Art, the which afterwards by Study is brought to some perfection. Yet the Practice of Art is not manifest but by Speculative Illustration: And for this cause I chose a Speculative Part; And first of Geometry that you may the better know the Practice.

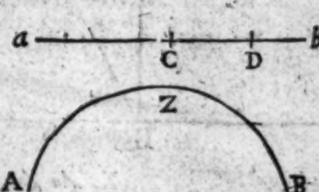
I. *A Point is that which hath no Part.*

A Point is supposed to be a Thing that cannot be divided into Parts, being the beginning of all Dimension. As the Point or Prick noted with the Letter A; and is but only the Term or end of Quantity.

A

II. *A Line is Length, without Breadth or Thickness.*

A Line's Extremes or Bounds are two Points, as you may see in the Line *a*, *b*. A Line is either straight or crooked. A Line is capable of Division in length only, and may be divided equally in the Point C, or unequally in D.



III. *A Right Line is the shortest of all Lines, drawn from any two Points.*

IV. *A Superficies has Longitude and Latitude only.*

A Superficies is that which hath only length and breadth. As in the first kind of Magnitude the Motion of a Point produceth a Line: So in the Second kind of Magnitude, the Motion of a Line produceth a Superficies. This is also capable of two Dimensions, as the length AB or CD, and the breadth AC or BD; and may be divided into any number of Parts.

V. *The Extremes of a Superficies are Lines.*

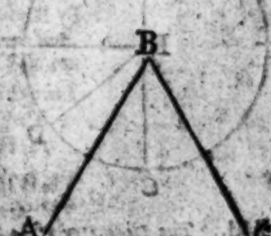
As the Ends of a Line are Points, so the Bounds or Extremes of a Superficies are Lines; as the Lines A B, BD, DC, and CA.

VI. *A Plain Superficies lieth equally between his Lines.*

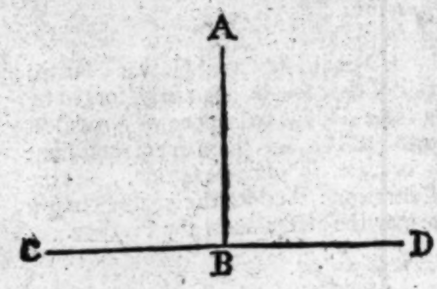
So the Superficies A B C D is that which lieth direct and evenly between his Lines, and is the shortest of all Superficies between the same Lines.

VII. *An Angle is when two Lines are extended in the same Superficies, inclining to each other; so that they meet together in a Point.*

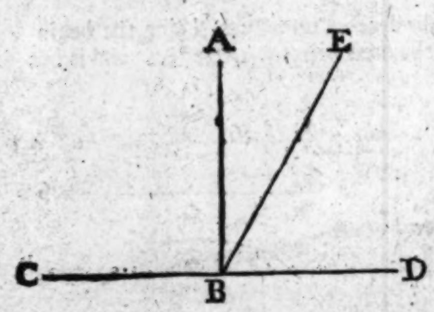
As you may see the two Lines A B and C B incline one towards the other, and touch one the other, in the Point B. In which Point, by reason of the inclination of the said Lines, is made the Angle A B C. And here note, That an Angle is most commonly signed by three Letters, the middlemost whereof sheweth the Angular Point, as when we say the Angle A B C, you are to understand the Angle at B.



VIII. *A Right Angle is that which is produced of a Right Line, falling upon a Right Line, and making two equal Angles on each side.*



As upon the Right Line CD suppose there stands another Right Line A B, in such sort that it maketh the Angles on either side thereof equal; namely, the Angle A B D on the one side, equal to the Angle A B C on the other side; then are either of these Angles, Right Angles; and the Right Line A B, which standeth erect upon the Right Line CD, without inclining to either part thereof, is Perpendicular to the Line C D.



IX. *An Obtuse Angle is that which is greater than a Right Angle.*

So the Angle C B E is an Obtuse Angle, because it is greater than the Right Angle A C B; for it doth not only contain that Right Angle, but the Angle A B E also, and therefore is Obtuse.

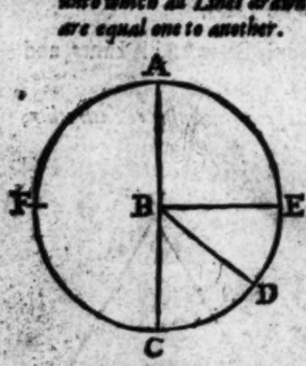
X. *An Acute Angle is less than a Right Angle.*

So you may see the Angle E B D is an Acute Angle; for it is less than the Right Angle A B D, in which is contained the other Acute Angle A B E.

XI. *A Figure is that which is contained under one Term, or many.*

As the Figure A is contained under one Limit or Term, which is a Circular Line; also the Figures B and C are each contained under four Right Lines: Likewise the Figure E is contained under three Right Lines; and the Figure F under five Right Lines, And so of all other Figures.

XII. *A Circle is a plain Figure contained under one Line, which is called the Circumference; unto which all Lines drawn from one Point within the Figure, which is called the Centre, are equal one to another.*



As this Figure is a Circle contained under the crooked Line A E C F, which Line is called the Circumference. In the middle of this Figure is the Point B, from which Point all Lines drawn to the Circumference are equal, as the Lines B A, B E, B D, B C; and this Point B is called the Center of the Circle.

XIII. *The Diameter of a Circle is a Right Line drawn by the Center thereof: and ending at the Circumference, on either side, divides the Circle into two equal Parts.*

So the Line A B C in the former Figure, is the Diameter thereof, because it passeth from

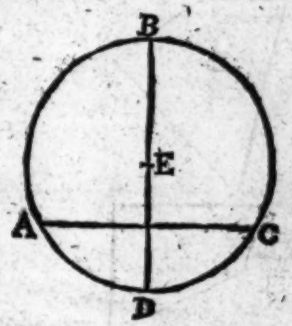
from the Point A on the one ſide, by the Point B, which is the Center of the Circle, and divideth the Circle into two equal parts, namely, A E C on one ſide of the Diameter, being equal to A F C on the other.

XIV. *A Semicircle is a Figure contained under the Diameter, and that part of the Circumference cut off by the Diameter.*

As in the former Circle, the Figure A F C is a Semicircle, becauſe it is contained by the Right Line A C which is the Diameter, and by the crooked Line A F C, being that part of the Circumference which is cut off by the Diameter: Alſo the part A E C is a Semicircle.

XV. *A Segment of a Circle, is a Figure contained under a Right Line, and a part of the Circumference, greater or leſs than a Semicircle.*

So the Figure A B C, which conſiſteth of the Part of the Circumference A B C, and the Right Line A C, is a Segment of the Circle, greater than a Semicircle.



Alſo the other Figure A C D, which is contained under the Right Line A C, and the part of the Circumference A D C, is a Segment of the Circle leſs than a Semicircle.

XVI. Right-lined Figures are ſuch as are contained under Right Lines.

XVII. Three-ſided Figures are ſuch as are contained under three Right Lines.

XVIII. Four-ſided Figures are ſuch as are contained under four Right Lines.

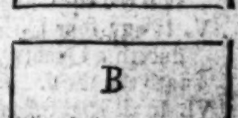
XIX. Many-ſided Figures are ſuch as have more Sides than four.

XX. All Three-ſided Figures are called Triangles:

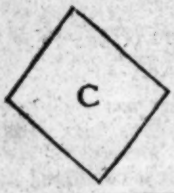
As the Triangles A, B, and C.

XXI. Of Four-ſided Figures, a Quadrat or Square is that whoſe Sides are equal, and its Angles right, as the Figure A.

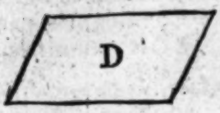
XXII. A Long Square is that which hath right Angles, but unequal Sides, as the Figure B.



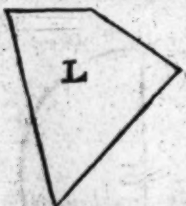
XXIII. A



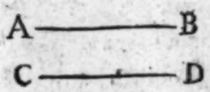
XXIII. A *Rhombus* is a Quadrangular Figure, having equal Sides, but not Right Angles, as the Figure C.



XXIV. A *Rhomboides* is a Figure whose opposite Sides are equal, and whose opposite Angles are also equal: but it hath neither equal Sides, nor Right Angles, as the Figure D.



XXV. All other Figures of Four Sides are called *Trapezia*'s, as L and M.



XXVI. Parallel or Equi-distant Right Lines, are such which being in one and the same Superficies, and produced infinitely on both sides, do never concur; as the two Lines AB, CD.

XXVII. A Solid is that which hath Length, Breadth and Thickness, as a Cube, (or Die;) as the Figure I: Or a Sphere or Globe, as the Figure K. The bounds of a Body are Superficies.

Geometrical Theorems.

I. ANY two Right Lines crossing one another, make the Vertical Angles equal. *Euclid.* 15. 1.

II. If any Right Line fall upon two parallel Right Lines, it maketh the outward Angle of the one, equal to the inward Angle of the other; and the two inward opposite Angles, on the contrary sides of the falling Line, also equal. *Euclid.* 27. 1.

III. If any side of a Triangle be produced, the outward Angle is equal to the two inward opposite Angles, and all the three Angles of any Triangle are equal to two Right Angles. *Euclid.* 32. 1.

IV. In Æqui-angled Triangles all their Sides are proportional, as well such as contain the equal Angles, as also the subtendent Sides. *Euclid.* 4. 6.

V. If any four Quantities be proportional, the first multiplied into the fourth, produceth a Quantity equal to that which is made by the Multiplication of the second into the third. *Euclid.* 16. 6.

VI. In all Right-Angled Triangles, the Square of the Side subtending the Right-Angle, is equal to both the Squares of the containing Sides. *Euclid.* 47. 1.

VII. All Parallelograms are double to the Triangles that are described upon their Basis, their Altitudes be equal. *Euclid.* 41. 1.

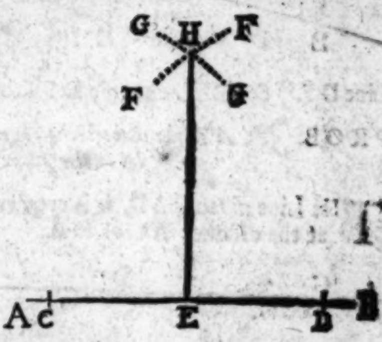
VIII. All Triangles that have one and the same Base, and lie between two Parallel Lines, are equal one to the other. *Euclid.* 37. 7.

Geometrical

Geometrical Problems.

PROB. 1. *Upon a Right Line given, how to erect another Right Line, which shall be perpendicular to the Right Line given.*

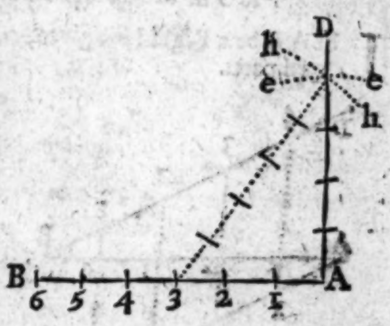
THE Right Line given is A B, upon which from the Point E it is required to erect the Perpendicular E H. Opening your Compasses to any convenient distance, place one foot in the assigned Point E, and with the other make the two Marks C nd D, equidistant on each side the Point E; then opening your Compasses again to any other convenient distance greater than the former, place one Foot in C, and with the other describe the Arch G G; also (the Compasses remaining at the same distance) place one Foot in the Point D, and with the other describe the Arch F F. Then from the Point where those two Arches intersect each other, which is at H, draw the Right Line H E, which shall be Perpendicular to the given Right Line A B, which was the thing required to be done.



PROB. 2. *To erect a Perpendicular on the end of a Right Line given.*

LEt B A, be a Line given, and let it be required to erect the Perpendicular A D. First upon the Line B A, with your Compasses opened to any small distance, make five small Divisions, beginning at A, noted with 1, 2, 3, 4, 5. Then take with your Compasses the distance from A to 4, place one Foot in A, and with the other describe the Arch e e: Then take the distance from A to 5, and placing one Foot of the Compasses in 3, with the other Foot describe the Arch h h, cutting the former Arch in the Point D: Lastly, from D draw the Line D A, which shall be perpendicular to the given Line A B.

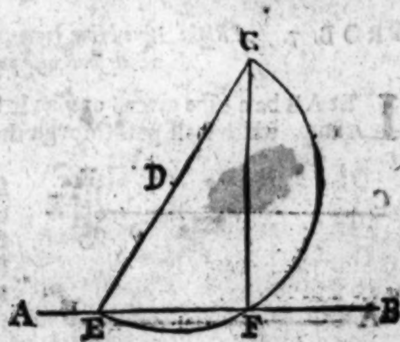
This Operation is grounded upon this Conclusion, *viz.* These three Numbers 3, 4, and 5, make a Right-angled Triangle, which is very necessary in many Mechanical Operations, and easy to be remembred.



PROB. 3. *To let fall a Perpendicular from a Point assigned on a Right Line given.*

THe Point given is C, from which Point it is required to draw a Right Line which shall be perpendicular to the given Right Line A B.

First from the given Point C, to the Line A B, draw a Line at pleasure, as C E, which divide into two equal parts in the Point D. Then placing one Foot of the Compasses in the Point D, with the distance D C, describe the Semicircle C F E, cutting the given Line A B in the Point F. Lastly, from the Point C draw the Right Line C F, it shall be a Perpendicular to the given Line A B, which was required.



PROB. 4. *How to make an Angle equal to an Angle given.*

LEt the Angle given be A C B, and let it be required to make another Angle equal thereunto.

First draw the Line E F at pleasure; then from the given Angle at C (the Compasses opened to any convenient distance) describe the Arch A B; and also from the Point F, the Compasses unaltered, describe the Arch D E; then take the Distance A B, and set the same from E to D: Lastly, draw the Line D F. So shall the Angle D F E be equal to the given Angle A C B.

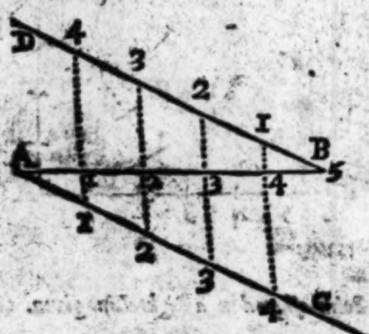
PROB. 5. *A Right Line being given, how to draw another Right Line which shall be parallel to the former, at any distance required.*

THe Line given is A B, it is required to draw another Right Line parallel thereunto, at the distance A C or D B.

First, Open your Compasses to the distance A C or B D; then placing one Foot in A, with the other describe the Arch C: also (at that distance) place one foot in B, and with the other describe the Arch D. Lastly, draw the Line C D, that it may only touch the Arches C and D: so shall the Line C D be parallel to the Line A B, and at the distance required.

PROB. 6. *To divide a Right Line into any number of equal Parts.*

LEt A B be a Right Line given, and let it be required to divide the same into five equal parts.



First, from one end of the given Line A B draw the Line A C, making an Angle therewith at pleasure. Then draw the Line B D, making the Angle A B D equal to the Angle C A B. Then from the Points A and B, set off upon these two Lines any number of equal Parts, being less by one than the Parts into which the Line A B is to be divided, which in this Example must be 4. Then draw small Lines from 1 to 4, from 2 to 3, and from 1 to 4, which Lines crossing the given Line A B shall divide it into five equal Parts, as was required.

PROB. 7. *A Right Line being given, how to draw another Right Line parallel thereunto, which shall also pass through a Point assigned.*

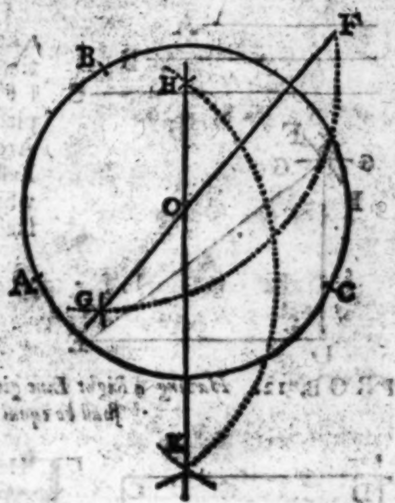
LEt A B be a Line given, and let it be required to draw another Line parallel thereunto, which shall pass through the given Point C.

First, Take with your Compasses the distance from A to C, and placing one foot at B, with the other describe the Arch D E; then take in your Compasses the whole Line A B, and place one foot in C, and with the other describe the Arch F G, crossing the former Arch in the Point H: then if you draw the Line C H, it shall be parallel to A B, as was required.

PROB. 8.

PROB. 8. *Having any three Points given which are not situated in a Right Line, how to find the Center of a Circle which shall pass through those three Points.*

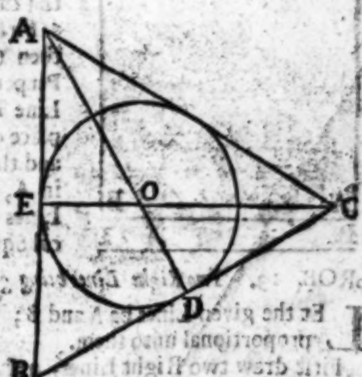
THe three Points given are A, B, and C; now it is required to find the Center of a Circle, whose Circumference shall pass through those three Points.



First, Open your Compasses to any distance greater than half the distance between B and C; then place one foot in the Point B, and with the other describe the Arch F G; then the Compasses remaining at the same distance, place one foot in the Point C, and with the other turn'd about make the Marks F and G in the former Arch, and draw the Line F O G.

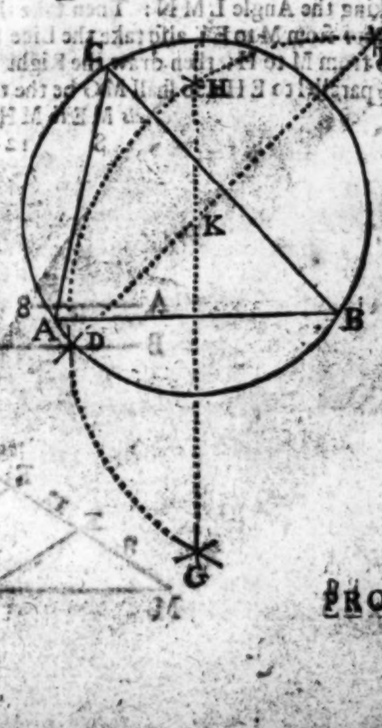
In like manner open your Compasses to a distance greater than half A C; place one foot in the Point A, with the other describe the Arch H K: then the Compasses remaining at the same distance, place one foot in the Point C, and turning the other about, make the Marks HK in the former Arch. Lastly, draw the Right Line H K, cutting the Line F G in O, so shall O be the Center, upon which you may describe a Circle at the distance of O A, and it shall pass through the three given Points A B C, which was required.

PROB. 9. *To describe a Circle in a Triangle, that shall only touch the three Sides.*



LEt the Triangle be A B C; then divide the Side of the Triangle A B in two equal parts, as at E, and draw the Line C E; and likewise divide B C equally, and draw the Line A D, where they cross one the other, as at O, that is the Center of the Circle: Therefore put one point of the Compass in in the Center O, and extend the other until it touch either side, and describe the Circle C D E, which will only touch the Sides of the Triangle A B C.

PROB. 10. *About a given Triangle to describe a Circle.*

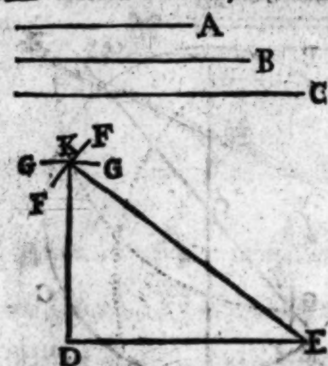


LEt the Triangle be A B C. This is only the eighth Problem in other words, that is; through the three Points A B C, to describe a Circle, and is performed as you see in the Figure.

PROB.

PROB. 11. *Any three Right Lines being given, so that the two shortest together be longer than the third, to make thereof a Triangle.*

Let it be required to make a Triangle of these three Lines A, B, and C, the two shortest whereof, *viz.* A and B together, are longer than the third C.



First draw the Line D E equal to the Line B; then take with your Compasses the Line C, and setting one foot in E, with the other describe the Arch F F: also take with your Compasses the Line A, and placing one foot in D, with the other describe the Arch G G, cutting the former Arch in the Point K. Lastly, from the Point K draw the Lines K E and K D, which shall constitute the Triangle K D E, whose sides shall be equal to the three given Lines A, B, C.

PROB. 12. *Having a Right Line given, How to make a Geometrical Square, whose sides shall be equal to the Right Line given.*

The Line given is R I, and it is required to make a Geometrical Square, whose Sides shall be equal to the Line R I.

First draw the Line A B equal to the given Line R I, then (by the second Problem) upon the Point B raise the Perpendicular B C, making the Line B C equal to the given Line R I; then taking the said R I in your Compasses, place one foot in C, with the other describe an Arch at D; and the Compasses being at the same distance, set one foot in A, and cross the former Arch at D; then draw the Lines D C and D A, which shall include the Geometrical Square A B C D, which was required.

PROB. 13. *Two Right Lines being given, to find a third which shall be proportional unto them.*

Let the given Lines be A and B; and it is required to find a third Line which shall be proportional unto them.

First draw two Right Lines, making any Angle at pleasure, as the Lines L M and M N making the Angle L M N: Then take the Line A in your Compasses, and set the length thereof from M to E; also take the Line B, and set the length thereof from M to F, and also from M to H; then draw the Right Line E H, and from the Point F draw the Line F G parallel to E H: So shall M G be the third proportional required: Arithmetically say,

As M E *to* M H: *So is* M F *to* M G.

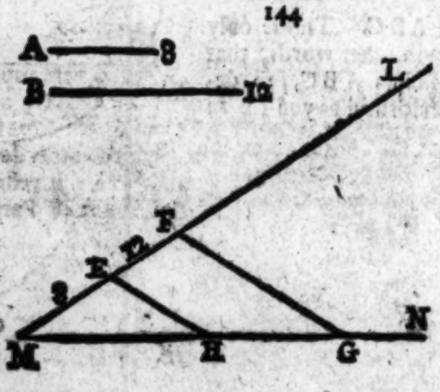
8 12 12 18

12 6(0

24 144 (18

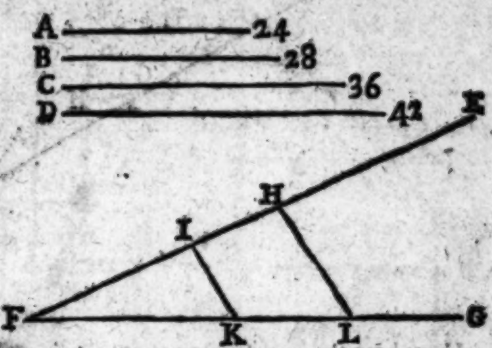
12 88

144



PROB. 14. *Three Right Lines being given, to find a fourth in proportion to them.*

THe three given Lines are A, B, C, unto which it is required to find a fourth Proportional Line D.



This is to perform the Rule of Three. As in the last Problem, you must draw two Right Lines, making any Angle at pleasure, as the Angle E F G; then take the Line A in your Compass, and set it from F to I; then take the Line B in your Compasses, and set that from F to K, drawing the Line I K, then take the third given Line in your Compasses, and set that from F to H, and from the Point H draw the Line H L, parallel to I K: So shall the Line F L be the fourth Proportional required.

Note, That these Lines are taken off a Scale, that is divided into 20 parts to an Inch.

To do it Arithmetically say,

As F I is to F K: So is F H to F L
24 28 36 42

28
288
72
1008

24
1008 (42
244
2

Here note, That in performance of the last Problem, the first and third Terms, namely the Lines A and C, are set upon one and the same Line, as here upon the Line F E, and the second Line B upon the other Line F G, upon which Line also the fourth Proportional will be found.

PROB. 15. *To work the Rule of Proportion by a Scale of equal Parts, and such other Conclusions as are usually wrought in Lines or Numbers.*

THe Scale of equal Parts will perform such Conclusions as are usually wrought in Lines or Numbers, as in *Gunter's* 10 *Prob.* 2. *Chap. Sector*, may be seen, and in others that have writ in the same kind. This way following *Foster* hath directed to in *Chap.* 1, of *Posthuma Fosteri*.

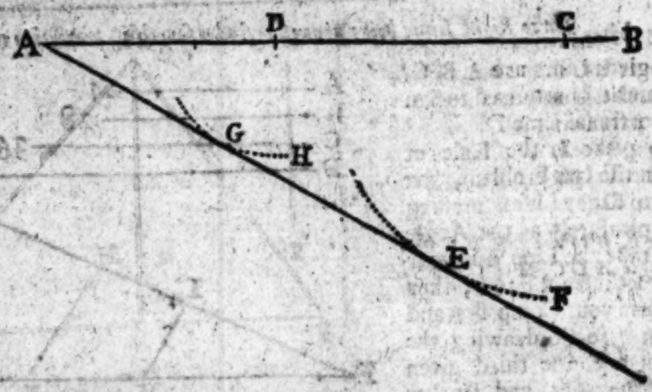
An Example in Numbers. As 16 to 7: So is 8 to a Fourth.

Here because the second Term is less than the first, upon the Line A B, I set A C the first Term 16, and A D the second Term 7, both taken out of the Scale of Equal Parts: thence also the third Number 8 being taken, with it upon the Center C, I describe the Arch E, and from A draw the Line A E, which may only touch the same Arch; then from D, I take D G, the least distance from the Line A E, and the same measured on the same Scale of Equal Parts gives $3\frac{1}{2}$, the fourth Term required.

But if the second Term be greater than the first, then the form of working must be changed, as in the following *Example*.

As 7 to 16: So 21 to a Fourth.

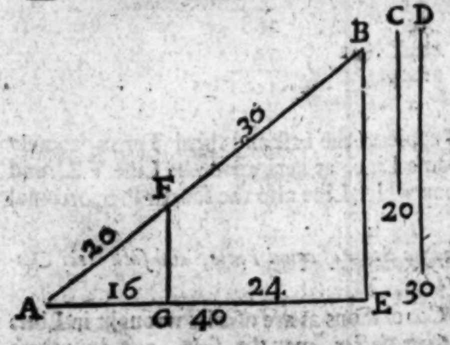
Upon the Line A B I set the second Term 16, which is here supposed to be A D; then with the first Term 7 upon the Center D, I describe the Arch G, and draw the Line A G that may just touch it: Again, having taken 21 out of the same Scale, I set one foot of that Extent upon the Line A B, removing it until that the other foot being turned about, will justly touch the Line A G before-drawn; and where it resteth, I make the Point C; then measuring A C upon your Scale, you shall find it 48 Parts, which is the fourth Number required.



I have been the more large upon this, because in the following Treatise I shall quote some other places in *Posthuma Fosteri*: and the Solution of Proportions must be referred thither, the form of their Operations being the same with this.

PROB. 16. *To divide a Right Line given, into two parts, which shall have such proportion one to the other as two given Right Lines.*

THe Line given is A E, and it is required to divide the same into two parts, which shall have such proportion one to the other, as the Line C hath to the Line D.



First, From the Point A draw a Right Line at pleasure, making the Angle B A E; then take in your Compasses the Line C, and set it from A to F; and also take the Line D, and set it from F to B, and draw the Line BE: Then from the Point F draw the Line F G, parallel to B E, cutting the given Line A E in the Point G: So is the Line A B divided into two parts in the Point G, in proportion to each other, as the Line C is to the Line D.

Arithmetically, Let the Line A E contain 40 Perches or Foot, and let the Line C be 20, and the Line D 30 Perches; and let it be required to divide the Line A E into two parts being in proportion one to the other, as the Line C is to the Line D.

First, Add the Lines C and D together, their Sum is A B 50: Then say by the Rule of Proportion, If 50 the whole Line A B, give 40 the whole Line A E: What shall 30 the greater given Term give? Multiply and divide, and you shall have in the Quotient 24 for the greater part of the Line A E; which being taken from 40, there remains 16 for the other part A G: For,

As A B is to A E: So is B F to E G.
50 40 30 24

40
20 00
1200 (24 120
550 1200

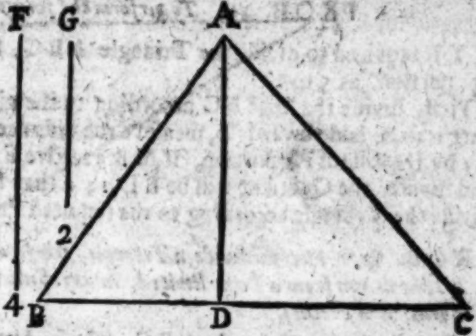
PROB. 17. *To divide a Triangle into two parts, according to any proportion assigned, by a Line drawn from any Angle thereof; and to lay the lesser part unto any Side assigned.*

LEt A B C be a Triangle given, and let it be required to divide the same by a Line drawn from the Angle A, into two parts, the one bearing proportion to the other, As the Line F to the Line G; and that the lesser part may be towards the Side A B.

By

By the last *Problem* divide the Base of the Triangle B C in the Point D, in proportion as the Line F is to the Line G (the lesser part being set from B to D,) and draw the Line A D, which shall divide the Triangle A B C in proportion as F to G.

As the Line F, is to the Line G : So is the Triangle A D C, to the Triangle A B D.



PROB. 18. *The Base of the Triangle being known, to perform the foregoing Problem Arithmetically.*

Suppose the Base of the Triangle B C be 45, and let the proportion into which the Triangle A B C is to be divided, be as 20 to 40. First add the two proportional Terms together, 20 and 40, which makes 60; then say by the *Rule of Proportion*, If 60, the Sum of the Proportional Terms, gives 45 (the whole Base B C,) What shall 40 the greater Term give? Multiply and divide, and the Quotient will give 30, for D C the greater Segment of the Base, which being deducted from the whole Base 45, there will remain 15 for the lesser Segment B D.

As 60 is to 45 : So is 40 to 30.

00	40
1800(30	1800
600	
6	

PROB. 19. *To divide a Triangle whose Area or Content is known into two Parts, by a Line drawn from an Angle assigned, according to any Proportion required.*

Let the former Triangle A B C contain 9 Acres, and let it be required to divide the same into two Parts, by a Line drawn from the Angle A, the one to contain 5 Acres, and the other 4 Acres. First, measure the whole length of the Base, which suppose 45; Then say, If 9 Acres the quantity of the whole Triangle, give 45 the whole Base, What parts of the Base shall 4 Acres give? Multiply and divide, the Quotient will be 20 for the lesser Segment of the Base B D; then draw the Line A D, which shall divide the Triangle A B C according to the proportion required.

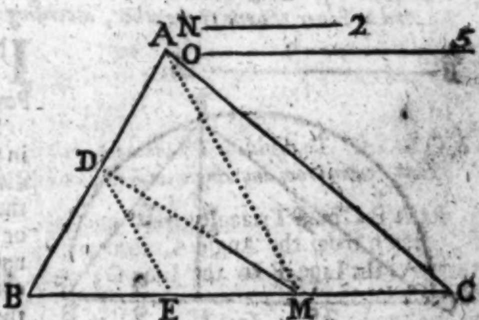
If 9 Acres give 45, What shall 4 Acres give? Answer 20.

00	45
180(20	4
99	180

PROB. 20. *To divide a Triangle given into two parts, according to any Proportion assigned, by a Line drawn from a Point given in any of the Sides thereof; and to lay the greater or lesser towards any Angle assigned.*

The Triangle given is A B C, and it is required from the Point M to draw a Line that shall divide the Triangle into two parts, being in proportion one to the other, as the Line N is to the Line O; and to lay the lesser part towards B.

First, from the limited Point M draw a Line to the opposite Angle at A; then divide the Base B C in proportion as O to N, which Point of Division will be at F; then draw F D parallel to A M: Lastly, from D draw the Line D M, which will divide the Triangle into two parts, being in proportion one to the other, as the Line O is to the Line N.



PROB.

PROB. 21. *To perform the foregoing Problem Arithmetically.*

IT is required to divide the Triangle ABC, from the Point M, into two parts in proportion, as 5 to 2.

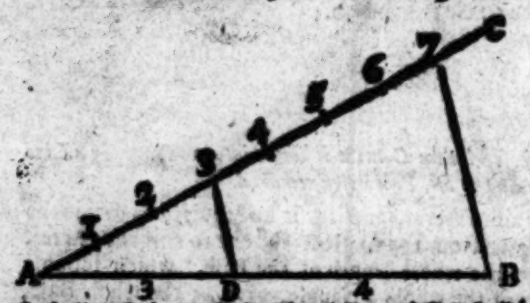
First, divide the Base BC according to the given Proportion; then because the lesser Part is to be laid towards B, measure the distance from M to B, which suppose 32: Then say by the Rule of Proportion, If MB 32, give FB 16, what shall AB 28 give? Multiply and divide, the Quotient will be BD 14; then from D draw the Line DM, which shall divide the Triangle according to the required Proportion.

PROB. 22. *How to divide a Triangle, whose Area or Content is known, into two Parts, by a Line drawn from a Point limited, in any Side thereof, according to any number of Acres, Roods, and Perches.*

IN the foregoing Triangle ABC, whose Area or Content is 5 Acres 1 Rood, let the limited Point be M in the base thereof; and let it be required from the Point M to draw a Line, which shall divide the Triangle into two parts between *Johnson* and *Powell*, so as *Johnson* may have 3 Acres, 3 Roods thereof, and *Powell* may have 1 Acre and 2 Roods thereof.

Reduce the quantities assigned to each of them into Perches, so *Johnson* hath 600, and *Powell* 240 Perches; then you are only to perform the foregoing *Problem*, that is, to divide a given Triangle from a Point assigned in one of the Sides, into two parts in proportion to each other, as 600 to 240, or as 5 to 2.

PROB. 23. *From a Line given, to cut off any Parts required.*



THE Line given is AB, from which it is required to cut off $\frac{3}{7}$ Parts.

First, draw the Line AC, making any Angle, as CAB; then from A set off 7 equal parts, as 1, 2, 3, 4, 5, 6, 7; and from 7 draw the Line 7 B. Now because $\frac{3}{7}$ is to be cut off from the Line AB, therefore from the Point 3 draw the Line 3 D, parallel to 7 B, cutting the Line AB in D, so shall AD be $\frac{3}{7}$ of the Line AB, and DB shall be $\frac{4}{7}$ of the same Line.

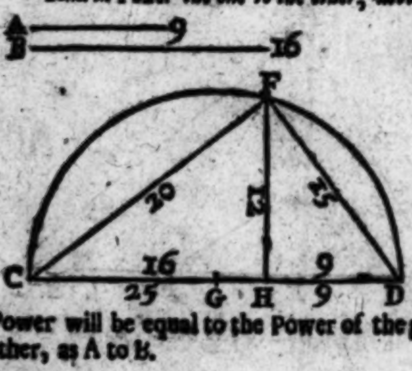
As A 7 is to AB: So is A 3 to AD.

PROB. 24. *To find a mean Proportional between two Lines given.*

IN the following Figure, let the two Lines given be A and B, between which it is required to find a Mean Proportional. Let the two Lines A and B be joined together in the Point H, making one Right Line as CD, which is divided into two equal Parts in the Point G; upon which Point G, with the distance GC or GD, describe the Semicircle CFD; then from the Point H raise the Perpendicular HF: So shall the Line HF be a Mean Proportional between the two given Lines A and B. For,

As HD is to HF: So HF to HC.
9 12 12 16

PROB. 25. *To find two Lines, which together shall be equal in Power to any Line given: And in Power the one to the other, according to any Proportion assigned.*



IN this Figure, let it be required to find two Lines equal in Power to CD, and in Power to each other, as A to B.

First, divide the Line CD in the Point H, in proportion as A to B (by *Prob.* 16.) then divide the Line CD into two equal Parts in the Point G, and on G, at the distance GD or GC, describe the Semicircle CFD, and upon the Point H raise the Perpendicular HF, cutting the Semicircle in F. Lastly, draw the Lines CF and DF, which together in Power will be equal to the Power of the given Line CD; and yet in Power one to the other, as A to B.

PROB.

PROB. 26. *How to divide a Triangle according to any Proportion given, by a Line drawn parallel to one of the Sides given.*

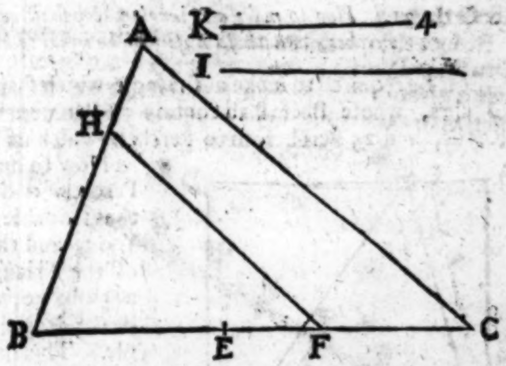
THe following Triangle A B C is given, and it is required to divide the same by a Line drawn parallel to the Side A C into two parts, which shall be in proportion one to the other, as the Line I is to the Line K.

First (by *Prob.* 16.) Divide the Line B C in E, in proportion as I to K; then (by *Prob.* 24.) Find a mean Proportional between B E and B C, which let be B F, from which Point F draw the Line F H, parallel to A C, which Line shall divide the Triangle into two parts, *viz.* the Trapezia A H F C, and the Triangle H F B, which are in proportion one to the other, as the Line I is to the Line K.

PROB. 27. *To perform the foregoing Problem Arithmetically.*

LEt the Triangle be A B C, and let it be required to divide the same into two parts, which shall be in proportion one to the other, as 4 to 5, by a Line drawn parallel to one of the Sides A C.

First, Let the Base B C, containing 54, be divided according to the proportion given; so shall the lesser Segment B E contain 24, and the greater E C 30; then find out the mean Proportional between B E 24, and the whole Base B C 54, by multiplying 54 by 24; whose Product will be 1296; the Square Root thereof is 36, the mean Proportional sought, which is BF. Then from the Point F draw the Line F H parallel to A C, which shall divide the Triangle, as was required.



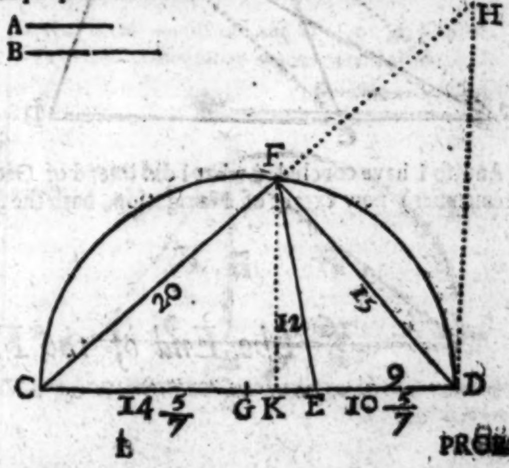
PROB. 28. *To divide a Triangle of any known Quantity into two Parts, by a Line parallel to one of the Sides, according to any Number of Acres, Roods, and Perches.*

THe Triangle given is A B C, whose Quantity is 8 Acres, 0 Roods, and 16 Perches; and it is desired to divide the same by a Line drawn parallel to the Side A C into two parts, *viz.* 4 Acres, 2 Roods, 0 Perches; and 3 Acres, 2 Roods, and 16 Perches.

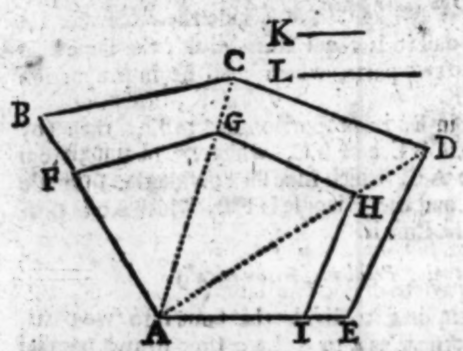
First, reduce both Quantities into Perches, and they will be 720, and 576; then reduce both these Numbers by abbreviation into the least proportional Terms, *viz.* 5 and 4; and according to that proportion, divide the Triangle A B C, by the preceeding Problem.

PROB. 29. *How to divide a Line in Power according to any Proportion given.*

IN this Figure, let it be required to divide the Line C D in Power as A to B. First, divide the Line C D in the Point E, in proportion as A to B: Then divide the Line CD in two equal parts in the Point G, and upon G as a Center, at the distance G D, describe the Semicircle F D C, and on E raise the Perpendicular E F, cutting the Semicircle in F: Then draw the Lines C F and D F, and produce the Line C F to H, till F H be equal to F D, and draw the Line D H. Lastly, draw the Line F K parallel to D H: Then shall the Line C D be divided in K; so that the Square of C K shall be to the Square of K D, as E C to E D, or as B to A.



PROB. 30. *To diminish a Plot given according to any Proportion required.*

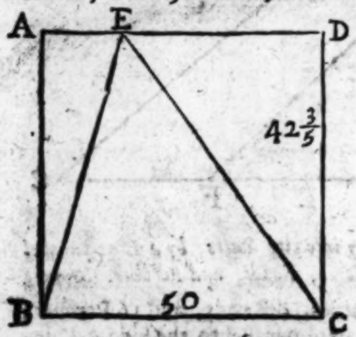


LEt A B C D E be a Plot given, to be diminished in Power as L to K.

Divide one of the Sides, as A B in Power as L to K, in the Point F, then from the Angle A draw Lines to the Points C and D. That done, from F draw a parallel to B C, cutting A C in G, as F G: Again, from G draw a parallel to D C, cutting A D in H. Lastly, from H draw a parallel to D E, cutting A E in I: So shall the Plot A F G H I be like A B C D E, and in proportion to it, as the Line L to the Line K, which was required.

PROB. 31. *How to make a Triangle which shall contain any Number of Acres, Roods, and Perches, and whose Base shall be equal to any (possible) Number given.*

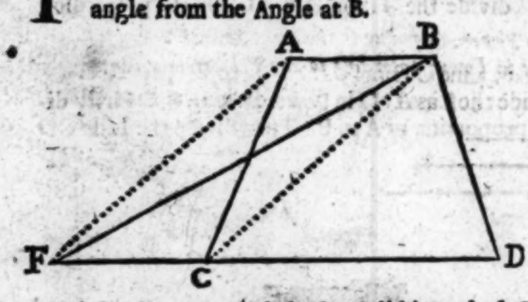
LEt it be required to make a Triangle which shall contain 6 Acres, 2 Roods, 25 Perches, whose Base shall contain 50 Perches. You must first reduce your 6 Acres, 2 Roods, and 25 Perches, into Perches, which makes 1065.



Now to make a Triangle that shall contain 1065 Perches, and whose Base shall be 50 Perches, do thus; double the number of Perches given, namely 1065, and they make 2130; then because the Base of the Triangle must contain 50 Perches, divide 2130 by 50, the Quotient will be $42\frac{3}{5}$ which will be the length of the Perpendicular of the Triangle. This done, from any Scale of equal parts, lay down the Line B C equal to 50 Perches; then upon C raise the Perpendicular C D, equal to $42\frac{3}{5}$ Perches, and from D draw the Line A D parallel to B C; then any Point in the Line A D, as to E draw the Lines B E, and C E, including the Triangle B E C, which shall contain 6 Acres, 2 Roods, 25 Perches, which was required.

PROB. 32. *To reduce a Trapezia into a Triangle, by a Line drawn from any Angle thereof.*

THe Trapezia given is A B D C, and it is required to reduce the same into a Triangle from the Angle at B.



First, extend the Line D C, and draw the Diagonal B C; then from the Point A draw the Line A F, parallel to C B, till it cut the extended Side D C in the Point F. Lastly, from the Point B draw the Line B F, constituting the Triangle F B D, which shall be equal to the Trapezia A B D C.

And so I have concluded what I did intend of Geometrical Problems, and no Book (as I remember) now extant of Navigation, hath the foregoing *Problems* so large

The End of the First Book.

The Second Book.

The Argument.

YOu're come to see a Sight, the World's the Stage;
Perhaps you'l say, 'Tis a Star-gazing Age.
Come out and see the Use of Instrument,
Can Speculation yield you such Content?
That you can rest in Learning but the Name,
Of flying Pegasus, *or swift* Charles-Wain?
And would you learn to know how he doth move
About his Axis, set at work by Jove?
If you would learn the Practice, read, and then
I need not thus intreat you by my Pen,
To tread in Arts fair Steps, or gain the way:
Go on, make haste, Delinquent, *do not stay.*
Or will you scale Olympick *Hills so high?*
Be sure take fast hold on Astronomy;
Then in that fair-spread Canopy no way
From thee is hid, no not Galaxia.
They that descend the Water's deep, do see
Our great God's Wonders there, and what they be.
They that contemplate on the Starry Sky,
Do see the Works that he hath fram'd so high.
Then learn the Worlds Division, and that Art
Which I shall shew you in this Second Part.

IN this Book is contained the Description, Making, and Use of the most necessary Instruments belonging to the Art of Navigation; as the Mathematical Ruler, on which are these Scales following; *viz.* The Line of Chords, Points, Leagues, Longitude, Natural Sines, Tangents, Secants, at one End; at the other are Dialling Scales, *viz.* The Chords and Gnomon Line, and Scale of six Hours; Scale of Inclination of Meridians, and two Scales for enlarging the Hour-lines, upon any reclining, inclining, or declining Plain without a Center, called the greater and lesser Pole: On the other Side are Lines of Artificial Sines, Tangents, and Numbers: A Meridian Line, according to Mr. *Edward Wright*'s Projection; and Tables for the making of these Scales, with a Line of Longitude and Reduction; also a useful Traverse-Scale, with a Table for to make it, with Artificial Rhombs for Points, Halves, and Quarters. Also the making of the Sinical Quadrant, and so ordered, that by the help of an Index, and Lines thereon, it shall answer many useful Questions in Astronomy and Navigation. Also the making the plain Sea-Chard, the true Sea-Chard, and particular Chards for any place; with the most useful and necessary Semicircle, that will protract any Course upon any Chard, without drawing Rhomb-Lines to fill the Chard; that so, by help of this Instrument, the Chard may serve for many Voyages. Also the Making and Use of a Compleat Instrument, on the back side of a Nocturnal, with 31 of the most noted Fixed Stars; which sheweth the hour of the Night that any Star cometh to the Meridian, with his Declination N. or S. Also a Table of the Declination, Right Ascension, Latitude and Longitude from *Tycho*'s Tables, rectified for the year 1671. On the other side a Nocturnal so ordered, that it shall give you the hour of the Night by the North-Star and brightest Guard, and his bearing from the Pole, whereby you may take the Declination; and it likewise sheweth the Suns place in the Ecliptick every day in the year; the making and the use of the Cross-staff, Back-staff, and Quadrant. As also a Kalendar shewing the Prime, Epact, and Dominical Letter; with a Table of the Suns Declination, and the use thereof.

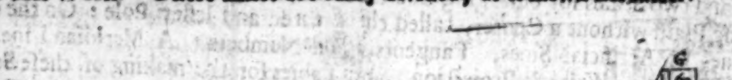
A Deſcription of Inſtruments.

CHAP. I. *Of Inſtruments in general.*

THe particular Deſcription of the ſeveral Inſtruments that have from time to time been invented for Mathematical Practice, would make a Treatiſe of it ſelf; and in this place it is not ſo neceſſary to be inſiſted on. To omit therefore the Deſcription of unneceſſary Inſtruments, I ſhall immediately begin with the Deſcription of thoſe which are the Grounds and Foundation of all the reſt, and are now the only Inſtruments in eſteem amongſt Navigators and Mariners at Sea, which are chiefly theſe; *viz.* The Mathematical Ruler, the Plain Scale, the Sinical Quadrant, the Plain Sea-Chard, and the true Sea-Chard, the particular Chard, the Semicircle or Protractor, the Nocturnal, the Croſs-ſtaff, Back-ſtaff, and Quadrant. Now as I would not confine any Man to the uſe of any particular Inſtrument; ſo I would adviſe every Man not to incumber himſelf with Multiplicity, ſince theſe aforeſaid are ſufficient for all Occaſions. Theſe Inſtruments have been largely deſcribed already by divers Authors; but ſome not fitted with Tables for the making of them. Therefore in this place it will be very neceſſary to give a particular Deſcription of them, that ſo if any man hath a deſire to any particular Inſtrument, he may give the better direction for the making thereof, or be able to make it himſelf.

Foraſmuch as there is a continual uſe both of Scales and Chards, which are on the Mathematical Scale, in drawing of Schemes in the Art of Navigation, and other Sciences in this Treatiſe; therefore we will give the Diagram of the Mathematical Scale, that Mariners may underſtand the making of them, which is commendable in an expert Mariner. I could wiſh that all Maſters and Mates were able to make their own Inſtruments, that if they ſhould be long at Sea, and by diſaſter break or loſe their Inſtruments, they may be able to make more themſelves.

For the Inſcription of the Chords, Sines, Tangents, and Secants, the Semidiameter AB muſt be divided into 100, 1000, 10000, or 100000 equal parts; and then by the Table of Natural Sines, Tangents, Secants, Chords, and Points, which I have fitted on purpoſe for this Work. Theſe Lines are eaſily divided, as is ſhewn hereafter.



fol. 22.

Here followeth a Table of Chords to every Deg. of the Quadrant. He that desires it larger, may take it to the parts of a Deg. The Chord is the Natural Sine of half the Arch doubled.

Example, If you double the Natural Line of 6. 15. 25. 30 Deg. you shall produce the Chords of 12. 30. 50. 60 Deg. thus 1045 is the Sine of 6 Deg. being doubled, the Sum will be 2090 the Chord of 12 Deg. and so of the rest, as in the Table following.

De	Chord	De	Chord	De	Chord	De	Chord	De	Chord	De	Chord
01	17	16	278	31	534	46	781	61	1015	76	1231
02	35	17	296	32	551	47	797	62	1030	77	1245
03	52	18	313	33	568	48	813	63	1045	78	1259
04	70	19	330	34	585	49	830	64	1060	79	1273
05	87	20	347	35	601	50	845	65	1074	80	1286
06	105	21	364	36	618	51	861	66	1089	81	1299
07	122	22	382	37	635	52	876	67	1104	82	1312
08	139	23	398	38	651	53	892	68	1118	83	1325
09	157	24	416	39	668	54	908	69	1133	84	1338
10	175	25	432	40	684	55	923	70	1147	85	1351
11	192	26	450	41	700	56	939	71	1161	86	1364
12	209	27	466	42	717	57	954	72	1176	87	1377
13	226	28	484	43	733	58	970	73	1190	88	1389
14	244	29	501	44	749	59	984	74	1204	89	1402
15	261	30	518	45	765	60	1000	75	1217	90	1414

This done, proportion the Radius of a Circle to what extent you please; make A B equal thereto, which must be divided into equal parts as before directed, and by this Table, the Chord of any Arch proportionable to this Radius, may speedily be obtained. For Example, Let there be required the Chord of 30 deg. the Number in the Table is 518; or in proportion to the Scale of 100 equal parts it is 52 almost; I take therefore 52 from the Scale of equal parts, and set them from B to 30 deg. upon the Line of Chords. Thus may you find the Chord of any other Arch agreeable to this Radius. Or if your Radius be of a greater or lesser extent, you must make A B equal thereto; only remember, that if the Chord of the Arch desired exceed 60 deg. you must continue the Line A B in the division of such parts, as need shall require. In this manner is made the Line of Chords in this Diagram answerable to that Radius. And in this manner you may find the Chord of the Points, halfs, and quarters, and the Sines, Tangents, and Secants of any Arch propor-

A Table for the Angles which every Rhomb maketh, with the Meridian, and the Chords of every Quarter Point of the Compasses.

North.	South.	deg.	min.	sec.	Chor	South.	North.	
		2	48	45	49			
		5	37	30	98			
		8	26	15	147			
N. b. E.	S. b. E.	11	15	00	195	S. b. W.	N. b. W.	1
		14	3	45	244			
		16	52	30	293			
		19	41	15	333			
N. N. E.	S. S. E.	22	30	00	390	S. S. W.	N. N. W.	2
		25	18	45	427			
		28	7	30	485			
		30	56	15	533			
N. E b. N.	S. E. b. S.	33	45	00	580	S. W. b. S.	N. W. b N.	3
		36	33	45	627			
		39	22	30	673			
		42	11	15	720			
N. E.	S. E.	45	00	00	767	S. W.	N. W.	4
		47	48	45	811			
		50	37	30	855			
		53	26	15	899			
N. E. b. E.	S. E. b. E.	56	15	00	942	S. W. b. W.	N. W. b. W.	5
		59	3	45	985			
		61	52	30	1028			
		64	41	15	1069			
E. N. E.	E. S. E.	67	30	00	1111	W. S. W.	W. N. W.	6
		70	18	45	1151			
		73	7	30	1190			
		75	56	15	1239			
E. b. N.	E. b. S.	78	45	00	1268	W. b. S.	W. b. N.	7
		81	33	45	1305			
		84	22	30	1343			
		87	11	15	1378			
East.	East.	90	00	00	1414	West.	West.	8

tionable to any Radius, by help of these Tables following; as by Example may more plainly appear.

Let there be required the Chord of the first Point in the Scale, 11 d. 15 m. in the Table.

The Number answering to 11 deg. 15 min. is 195; I take therefore with my Compasses 19, or reckon so many on the Scale of equal parts, which is joyned with a Line intended to be made; and so with a Square for that purpose, as shall be shewed, mark from F towards 8 the first Point 11 deg. 15 min. the Radius of the Circle being A B; and so of the rest.

A Table to divide the Line of Longitudes.

M.	Chords d.	sec.	M.	Chords d.	sec.	M.	Chords d.	sec
1	89	02	21	69	30	41	46	54
2	88	06	22	68	29	42	45	35
3	87	08	23	67	28	43	44	12
4	86	11	24	66	25	44	42	49
5	85	14	25	65	23	45	41	26
6	84	16	26	64	20	46	40	00
7	83	18	27	63	15	47	38	28
8	82	20	28	62	11	48	36	54
9	81	22	29	61	06	49	35	16
10	80	24	30	60	00	50	33	34
11	79	26	31	58	53	51	31	45
12	78	27	32	57	46	52	29	58
13	77	29	33	56	38	53	27	59
14	76	30	34	55	29	54	25	53
15	75	31	35	54	18	55	23	33
16	74	31	36	53	09	56	21	06
17	73	32	37	51	56	57	18	13
18	72	32	38	50	42	58	14	50
19	71	32	39	49	26	59	10	26
20	70	31	40	48	11	60	00	00

THe Line of Longitude is divided by help of this Table, the use of which is very easie; for in the first, third and fifth Colums are the min. of Longitude on the Line of Longitude; and in the second, fourth, and sixth, the Chords in deg. and min. against which the min. of Longitude are to be divided: Therefore having divided a Line of Chords to 90, you may divide the Line of Longitude thereby.

Examp. 1 Min. of Longitude is against 89 d. 2 min. on the Chords, 2 min. against 88 d. 6 m. 3 min. against 87 d. 8 m. and so of the rest.

The use of this Scale is to find how many min. of the Equinoctial make a deg. of Longitude in any Parallel of Latitude.

Examp. In the Latitude of 40 deg. how many min. (or Miles) make 1 deg. of Longitude? Extend your Compasses on the Line of Chords from the beginning of the deg. to 40 deg. that extent shall reach from 60 min. on the Line of Longitude, to 46 min. and so many min. make a deg. of Longitude in that Latitude.

A Table of Natural Sines to the Radius of 1000.

De	Sines	De	Sines	De	Sines	De	Sines	De	Sines	De	Sines
1	17	16	276	31	515	46	719	61	875	76	970
2	35	17	292	32	530	47	731	62	883	77	974
3	52	18	309	33	545	48	743	63	891	78	978
4	70	19	326	34	559	49	755	64	899	79	982
5	87	20	342	35	574	50	766	65	906	80	985
6	105	21	358	36	588	51	777	66	914	81	988
7	122	22	375	37	602	52	788	67	921	82	990
8	139	23	391	38	616	53	799	68	927	83	993
9	156	24	407	39	625	54	809	69	934	84	995
10	174	25	423	40	643	55	819	70	940	85	996
11	191	26	438	41	656	56	829	71	946	86	998
12	200	27	454	42	669	57	839	72	951	87	999
13	225	28	469	43	682	58	848	73	956	88	999
14	242	29	485	44	695	59	857	74	961	89	1000
15	259	30	500	45	707	60	866	75	966	90	1000

A Sine is a Right Line, falling from the end of an Arch perpendicular to the Diameter, which is drawn to the other end of the Arch; so C D is a Sine of 60 deg. By this Table of Natural Sines, to every deg. of the Quadrant which I have fitted for this purpose, whose Ra- is 1000, you shall find Sine of 90 deg. to be 866. I take therefore with my Compasses 86 from my Scale of equal parts, and set them from A towards 8 in the Line of Sines for 60 deg. (where the Radius of the Circle is A B,) and the Number in the Table answering 30 deg. is 500; take therefore with your Compasses 50 equal parts of A B, and lay it from A upon the Line of Sines for 30; and so of the rest.

A Tangent is a Right Line touching the Circle, and is limited by the Secant; as B G in the Diagram, which is the Tangent of the Arch B C 60 deg. and in the Table of Tangents you shall find it to be 1732 equal parts; therefore take with your Compasses 173 parts, and that will reach from B to G, the Tangent of 60 deg. in the Scale, and the Tangent 30 deg. is 577 parts; therefore take 57 parts, and it will reach from B to the length of 30 deg. and so of the rest.

A Table of Natural Tangents to every Degree of the Quadrant.

De	Tan.	De	Tan.	De	Tan.	De	Tan.	De	Tangents
1	17	19	344	37	754	55	1428	73	3271
2	35	20	364	38	781	56	1483	74	3487
3	52	21	384	39	810	57	1540	75	3732
4	70	22	404	40	839	58	1600	76	4011
5	87	23	424	41	869	59	1664	77	4331
6	105	24	445	42	900	60	1732	78	4705
7	123	25	466	43	933	61	1804	79	5145
8	141	26	488	44	966	62	1881	80	5671
9	158	27	510	45	1000	63	1963	81	6314
10	176	28	532	46	1036	64	2050	82	7115
11	194	29	554	47	1072	65	2145	83	8144
12	213	30	577	48	1110	66	2246	84	9514
13	231	31	601	49	1150	67	2356	85	11430
14	249	32	625	50	1132	68	2475	86	14301
15	268	33	649	51	1285	69	2605	87	19081
16	287	34	675	52	1290	70	2747	88	28636
17	306	35	700	53	1327	71	2904	89	57290
18	325	36	727	54	1377	72	3078	90	Infinite.

A Secant is a Line drawn from the Center of the Circle, until it meet with the Tangent Line; as A G in the foregoing Diagram cuts the Tangent of the Arch B C 60 deg. in G: so the Secant of 60 deg. in this Table of Secants is found 2000 equal parts; therefore take off 200, it shall reach from A to G for the Secant of 60 deg. and the Secant of 30 deg. in this Table is found to be 1155; therefore take with your Compasses 115 equal parts, and it shall reach from A towards G for the Secant of 30 deg. as you may find by the Scale in the Diagram.

A Table of Secants to every Degree of the Quadrant.

De	Sec.	De	Sec.	De	Sec.	De	Sec.	De	Secants.
1	1000	19	1058	37	1252	55	1743	73	3420
2	1001	20	1064	38	1269	56	1788	74	3628
3	1001	21	1071	39	1287	57	1836	75	3864
4	1002	22	1078	40	1305	58	1887	76	4133
5	1004	23	1086	41	1325	59	1942	77	4445
6	1005	24	1095	42	1346	60	2000	78	4810
7	1007	25	1103	43	1367	61	2063	79	5241
8	1010	26	1113	44	1390	62	2130	80	5759
9	1012	27	1123	45	1414	63	2203	81	6392
10	1015	28	1132	46	1439	64	2281	82	7185
11	1019	29	1143	47	1466	65	2366	83	8205
12	1022	30	1155	48	1494	66	2458	84	9567
13	1026	31	1167	49	1524	67	2559	45	11474
14	1031	32	1179	50	1556	68	2669	86	14335
15	1035	33	1192	51	1589	69	2790	87	19107
16	1040	34	1206	52	1624	70	2924	88	28654
17	1046	35	1221	53	1662	71	3071	89	57299
18	1051	36	1236	54	1701	72	3236	90	Infinite.

A Versed Sine is found by subtracting the Sine Complement out of the Radius. *Examp.* For to know the Versed Sine of 60 deg. you must subtract the Sine of 30 deg. *viz.* 500 out of the Radius 1000, or Sine of 90, A B, the remain will be D B 500, for the Versed Sine of the Arch B C 60 deg. In like manner the Versed Sine of 30 deg. is 134; and so work in like manner for any other deg.

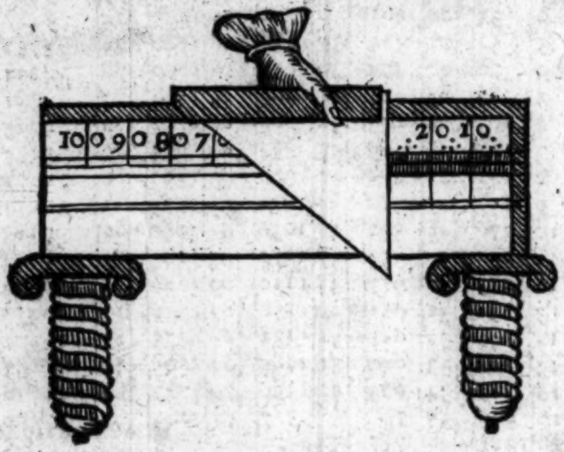
CHAP. II.

Describing what Instruments of Brass, Steel, Iron, and Wood you must provide before you can make Instruments for Mathematical Uses.

Before we explain the other part of the Diagram, it will be necessary for to give a Description of what Instruments in Brass, Steel, Iron, or Wood you must have by you in readiness, before you can make a Mathematical Instrument; That Men that are ingenious

ingenious, may be provided in ſome meaſure with ſuch before they go to Sea, to ſpend their ſpare time on this Practice.

Firſt, For Inſtruments of Wood, you muſt be provided with ſeveral Scales of equal parts, of different lengths, according to the Radius of thoſe Lines you intend to divide.



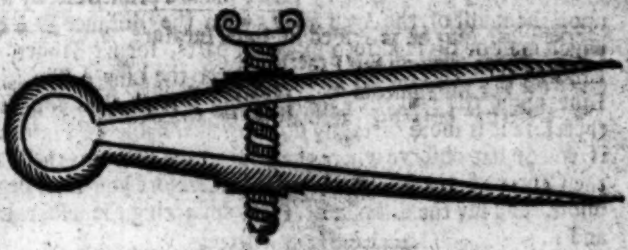
You muſt be fitted with ſome pieces of Box, dry, clean from Knots, ſtraight, and ſmooth planed, or other Wood, on which you may make what Scale you pleaſe. You muſt have by you a Square of Braſs and Wood, ſuch as you may ſee in this Figure, with a pair of Cramps made of Iron, with Screws to faſten the Scale of equal Parts, to the Scale to be made, ſo as they may not ſlip. Or for ſmall Scales, you may faſten the Scale of equal parts, and the Scale to be made by it, on a piece of DealBoard, with the Heads of Scuper Nails, ſo as they may not ſtir; but for greater Inſtruments, Croſs Staves, and Gauging Rods, you muſt divide them as this Figure. You muſt have a Gauge made of Braſs, with a good Steel Pin, for the drawing of ſtraight Lines on your Scale, for the diviſion of the Columns for Graduation. You muſt have two or three Sorts and Sets of Steel Letters and Figures, and Figures for Ornament, with a neat Hammer to uſe with them: And the Figures, Letters, and Ornament-Figures, ſet in an Alphabet-Box, with written Letters and Figures before them, for the ready finding of them; with Characters of the Signs, Planets, and Stars.

The Inſtrument that you divide with, the Edge muſt be very thin and ſharp, and you may have ſeveral of them; or the end of a Pen-Knife may do for a ſhift. You muſt have a Braſs pair of Compaſſes to go with an Arch and Screws, to faſten at any diſtance, and four Steel Points to take in and out; two long Points for to reach a great diſtance, and two other ſhort Points; one is to be made round for a Center-Point, that it may not go two far into the Wood; and the other pointed like a Dutch-Knife, and the Shoulder fitted ſquare to be faſtned, and taken in and out at pleaſure. The uſe of theſe Points is to draw Circles on round Inſtruments, as Nocturnals, and the like. You may have two pair of Dividers, the leaſt three Inches and a half long. I eſteem them beſt that are made with a Bow at the Head, and to be ſet together by a Screw in the middle. Be ſure they be made of good Steel. Theſe are to divide Equal Parts, or any other Equal Diviſion. You muſt have for great Inſtruments, as Bows, Quadrants, and the like, a pair of Beam-Compaſſes, for to ſweep the Arches of them. You ſhould have a Hand-Vice, ſo made as to ſcrew into the edge of a Board for your uſe, and to take out again; with three or four ſorts of ſmall Files, for to file and make Pins, which you will have occaſion for. Take Charcoal, and beat it to a fine Powder, and temper it with Linſeed-Oyl; and let it be rubb'd on the Inſtrument newly divided, and lie ſo on it for a time, until it be pretty dry; and then with ſome Sallet-Oyl rub the Inſtrument, and make it clean. So will you have the Graduation and Figures ſet off very neatly on Box Inſtruments, with black.

And now I have ſhewn the Practitioner what Inſtruments he muſt be furniſhed with, I will return to the Explanation of the other part of the Diagram of the Mathematical Ruler.

CHAP.

The Figure of the Gauge.

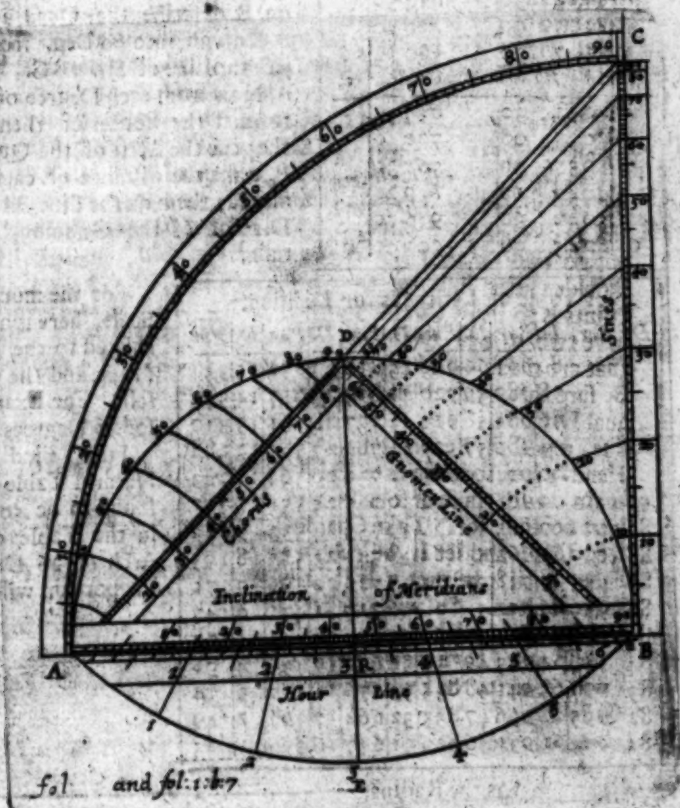


The Figure of the Dividers.

CHAP. III.

The Explanation of the other part of the Diagram, being a Description of the Dialling-Scales on the Mathematical Ruler.

THis annexed Diagram sheweth plainly the Description of the Dialling-Scales on the Mathematical Ruler; it being the most easie Instrument used in that Art, as will be manifest in the Seventh Book.



How to make the Diagram. First, make a Semicircle by a less Radius, as A D B, and upon the midst of the Arch at D, with the distance D A describe the Quadrant A E B, which must be divided into six equal parts, for six Hours, and from each point draw Lines to the Center at D; so will it cut the Line A B in 1, 2, 3, 4, 5, 6, for the Hour Lines upon the said Scale for Dialling: And thus you see it is a Tangent Line, and therefore it is more certainly done by this Table of Natural Tangents for three Hours, if you do but observe where the Right Line D E cuts the Tangent Line A B, which is in the Center of the Semicircle at R; therefore you must begin to make this Scale in the midst, and lay the distance of Parts answering the Hours both ways from R towards B and A.

Example, To Graduate 2 Hours and 4 Hours, you see in the Table, the Number answering to 2 Hours and 4 Hours in the first and last Columns; is in the third 15 Degrees, and in the fourth Column the Tangent is 268; therefore if you take 268 such parts whereof the Semidiameter R B is divided into 1000, as was shewed in the former Diagram; and put one Foot of the Compasses with that extent at R (the midst or 3 Hours,) and turn the other toward B, it will make the distance of 4 Hours; and turn that distance towards A, it will be 2 Hours of the Scale: and so do with the rest of the Hours and Minutes.

A Table for dividing the Hours and Minutes on the Dialling-Scale.

Ho.	*M*	*D.*	*M.*	*Tangents.*	*M*	*Ho.*
3	10	2	30	44	50	
	20	5	00	87	40	
	30	7	30	132	30	
	40	10	00	176	20	
	50	12	30	222	10	
4	60	15	00	268	60	2
	10	17	30	315	50	
	10	20	00	364	40	
	30	22	30	414	30	
	40	25	00	466	20	
	50	27	30	520	10	
5	60	30	00	577	60	1
	10	32	30	637	50	
	20	35	00	700	40	
	30	37	30	767	30	
	40	40	00	839	20	
	50	42	30	916	10	
6	60	45	00	1000	00	0

In like manner for the Scale of Inclination of Meridians, you must take the Tangent out of the Table of Tangents to every Degree, and graduate in the same manner as before, from the Center which is the midst of the Scale at 45 Degrees, as is plain in the Diagram.

For the Gnomon-Line, or as others call it, the Line of Latitude, let B A be the Semidiameter; and on B describe the Quadrant A B C, whose Arch A C divide into 90 Deg. from whence you may project the Line of Sines B C.

Now from each Degree of those Sines, draw Lines toward the Center of them at A, and note where they cut the Arch of the Quadrant B D; then from B, take the distance of each of these Intersections, and lay them on the Line B D: So shall you have the Division of the Gnomon-Line, or Line of Latitude.

A Table of Latitudes for Dialling.

D.	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par.*
		80	991	60	926	45	816	30	632	15	354
		78	989	59	920	44	807	29	617	14	332
		76	985	58	915	43	797	28	601	13	310
		74	980	57	909	42	787	27	585	12	288
		72	974	56	903	41	776	26	568	11	263
90	1000	70	968	55	896	40	765	25	551	10	242
89	1000	69	965	54	889	39	753	24	533	9	219
88	1000	68	961	53	882	38	741	23	515	8	195
87	999	67	958	52	875	37	729	22	496	7	171
86	999	66	954	51	868	36	717	21	477	6	147
85	998	65	950	50	860	35	704	20	458	5	123
84	998	64	945	49	852	34	690	19	438	4	98
83	997	63	941	48	844	33	676	18	418	3	74
82	995	62	936	47	835	32	662	17	397	2	49
81	994	61	931	46	826	31	647	16	376	1	25

For the more ready making of this Scale, here is a Table of Latitudes calculated to the 90 Degrees of the Quadrant, and the way to calculate it your self. For Example, To find the Parts for 30 Degrees of Latitude.

First, Find the Sine thereof in the Natural Table of Sines, which will be found to be 50000; which sought for in the Table of Tangents, giveth an Arch of 26 Deg. 34 Min. Then the Proportion will hold,

As the Radius	100000
To the Secant 45 Deg.	141421
So is the Sine of 26 Degrees 34 Minutes	44724
Unto the Parts for the Latitude	63249

Which

Which anſwers to the Radius 100000 : But in the Table the Parts 632 anſwer to the Radius 1000, which will be ſufficient for the Graduating the Line of *Gnomons* or Latitude.

And to make 30 Degrees of Latitude on your Scale, you muſt take off 632 ſuch Parts as the Line B D is divided into 1000, as you have been ſhewn in the former Diagram.

How to make the Line of Chords, you have been fully inſtructed already in the former Figure; which is only by dividing the Arch of the Quadrant A D into 90 equal parts; and from A take the diſtance, and lay them down in a ſtraight Line A D: So ſhall you have the Line of Chords: Or you may do it by the Table of Chords, as before-directed.

How to make the two Lines or Scales of inlarging Hour-lines upon any reclining Plain, without a Center, called (by me) the greater and the leſſer Pole.

Here you have a Table ready fitted for the making thereof. Firſt, You muſt make choice of the length of this Scale, that is in Proportion to the former Lines of the Scale.

The firſt 3 Hours muſt be divided into 10 parts, and each of them into 10 more, as you have been ſhewn. You muſt have two of theſe Lines of Equal Parts, of two proportionable Lengths, for the greater and leſſer Pole; and ſo take of the Tangent-parts anſwerable to every 5 Minutes of an Hour: As you ſee the firſt and ſecond Columns of the Table are Hours and Minutes, the third Degrees and Minutes, and the fourth Tangents. So the Tangent of the firſt 2 Hours of the Scale or 30 Degrees, is 577 Parts; take of your two Scales 57 Parts; firſt, of the largeſt Radius for 2 Hours on the greater Scale, and the like number of the ſmaller Radius (or Line of equal Parts) for two Hours of the leſſer Scale. And ſo in the ſame manner you muſt work to finiſh the whole Scales of what Radius you pleaſe, by theſe Tables, as hath been directed.

The uſe hereof is fully ſhewn in the Seventh Book of the *Art of Dialling*.

Theſe Scales are ſufficient to make any ſort of Dials, in any Latitude (as is here ſhewn) with great eaſe.

There are two Lines, called by the Names of Style and Subſtyle; but they are only for one Latitude, but may be found for any. But the Scales before-explained are moſt uſeful, and do the ſame thing, as you will find in the *Art of Dialling*. And theſe are the Scales on one Side of the Ruler.

A Table of Tangents for 5 Hours to every 5 Minutes of an Hour, for inlarging the Hour-Lines.

Ho.	M.	D.	M.	Tang.	Ho.	M.	D.	M.	Inag.
	5	1	15	22		5	46	15	1044
	10	2	30	44		10	47	30	1091
	15	3	45	65		15	48	45	1140
	20	5	00	87		20	50	00	1192
	25	6	15	109		25	51	15	1246
	30	7	30	132		30	52	30	1303
	35	8	45	154		35	53	45	1364
	40	10	00	176		40	55	00	1428
	45	11	15	199		45	56	15	1497
	50	12	30	222		50	57	30	1570
	55	13	45	245		55	58	45	1648
1	60	15	00	268	4	60	60	00	1732
	5	16	15	291		5	61	15	1823
	10	17	30	311		10	62	30	1921
	15	18	45	335		15	63	45	2028
	20	20	00	364		20	65	00	2044
	25	21	15	389		25	66	15	2273
	30	22	30	414		30	67	30	2414
	35	23	45	406		35	68	45	2571
	40	25	00	466		40	70	00	2748
	45	26	15	493		45	71	15	2946
	50	27	30	520		50	72	30	3171
	55	28	45	548		55	73	45	3431
2	60	30	00	577	5	60	75	00	3732
	5	31	15	607					
	10	32	30	637					
	15	33	45	668					
	20	35	00	700					
	25	36	15	733					
	30	37	30	767					
	35	38	45	802					
	40	40	00	839					
	45	41	15	877					
	50	42	30	916					
	55	43	45	957					
3	60	45	00	1000					

CHAP.

CHAP. IV.

The Scales or Lines on the back-side of the Mathematical Ruler, are these: A Line of Numbers, a Line of Artificial Tangents, a Line of Sines, a Meridian Line according to Mr. Wright's *Projection; and the Scale of equal Parts, by which the Numbers were taken off for the Graduating these Scales; and a Line of Longitude, with a Scale of Reduction.*

I. TO divide the Line of Numbers, you must prepare a Ruler of what length you please, and also a Scale of equal parts, divided into 100 or 1000. But if you divide the Artificial Tangents and Sines with the Line of Numbers, it is best to divide the Line into 2000 parts. This Table is taken out of the Logarithms, by rejecting the Index or first Figure, and as many of the last Figures as you see convenient, according to the length of your Line. Then suppose you were to make the first 2 or 20, take with your Compass 301 equal Parts, and lay it from 1 to 2, and the same distance will reach from 10 in the middle to 20. In the like manner do with the rest; for 3 or 30 equal Parts is 477, and for 4 or 40, the Log. Parts is 602: as you may easily perceive, by what is written.

A Table for the Division of the Line of Artificial Numbers.

Num.	Log. Parts.	Num.	Log. Parts.	Num.	Log. Parts.	Num.	Log. Parts.	Num.	Log. Parts.
1	00	21	322	41	612	61	785	81	908
2	30	22	342	42	623	62	792	82	914
3	48	23	362	43	633	63	799	83	919
4	60	24	380	44	643	64	806	84	924
5	70	25	398	45	653	65	813	85	929
6	78	26	415	46	663	66	819	86	934
7	84	27	431	47	672	67	826	87	939
8	90	28	447	48	681	68	832	88	944
9	95	29	462	49	690	69	839	89	949
10	100	30	477	50	700	70	845	90	954
11	41	31	491	51	707	71	851	91	959
12	79	32	505	52	716	72	857	92	964
13	114	33	518	53	724	73	863	93	968
14	146	34	531	54	732	74	869	94	973
15	176	35	544	55	740	75	875	95	978
16	204	36	556	56	748	76	880	96	982
17	230	37	568	57	756	77	886	97	987
18	255	38	580	58	763	78	892	98	991
19	279	39	591	59	771	79	898	99	996
20	301	40	602	60	778	80	903	100	1000

II. *To divide the Line of Artificial Tangents on the Ruler.*

THe Artificial Tangents are made in the same manner as other Lines before-directed; beginning at 1 on the Line of Numbers. So 106, taken off the former Scale, and applied upward, will make 40 Minutes on your Scale; for 1 and 89 Degrees the Part answering thereunto is 242, with them do in like manner, and so of the rest, until you have finished the whole Line or Scale, as you may see in the Figure.

III. *A Table for the Division of the Line of Artificial Tangents into Degrees and Minutes.*

Min.	Deg. Tang.	Deg Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Deg. Tang.	Min.
Min.	0	1	2	3	4	5	6	7	8	9	10	11	Min.
0	00	242	543	719	845	942	1022	1089	1148	1200	1246	1289	60
10	46	308	578	743	862	956	1034	1099	1157	1208	1254	1295	50
20	76	367	610	765	879	970	1045	1110	1166	1216	1261	1305	40
30	94	418	640	786	896	983	1057	1119	1174	1224	1268	1308	30
40	106	464	668	807	912	997	1068	1129	1183	1231	1275	1315	20
50	163	505	694	826	927	1009	1078	1138	1191	1239	1282	1321	10
Min.	89	88	87	86	85	84	83	82	81	80	79	78	Min.
Min.	12	13	14	15	16	17	18	19	20	21	22	23	Min.
0	1327	1363	1396	1428	1457	1485	1512	1537	1561	1584	1606	1628	60
10	1334	1369	1402	1433	1462	1490	1516	1541	1565	1588	1610	1631	50
20	1340	1375	1407	1438	1467	1494	1520	1545	1569	1592	1614	1635	40
30	1346	1380	1413	1443	1472	1499	1524	1549	1573	1595	1617	1638	30
40	1352	1386	1418	1448	1476	1503	1529	1553	1576	1599	1621	1642	20
50	1358	1391	1423	1453	1480	1507	1533	1557	1580	1603	1624	1645	10
Min.	77	76	75	74	73	72	71	70	69	68	67	66	Min.
Min.	24	25	26	27	28	29	30	31	32	33	34	35	Min.
0	1648	1669	1688	1707	1726	1744	1761	1779	1796	1812	1829	1845	60
10	1652	1672	1691	1710	1729	1747							50
20	1655	1675	1694	1713	1732	1750	1767	1784	1801	1818	1834	1850	40
30	1659	1678	1698	1716	1735	1753							30
40	1662	1682	1701	1719	1738	1755	1773	1790	1807	1823	1840	1856	20
50	1665	1685	1704	1723	1741	1758							10
Min.	65	64	63	62	61	60	59	58	57	56	55	54	Min.
Min.	36	37	38	39	40	41	42	43	44	45			Min.
0	1861	1877	1893	1908	1924	1939	1954	1970	1985	2000			60
20	1866	1882	1898	1913	1929	1944	1959	1975	1990				40
40	1872	1887	1903	1919	1934	1949	1964	1980	1995				20
Min.	53	52	51	50	49	48	47	46	45				Min.

IV. *To divide the Scale or Line of Artificial Sines into degrees and minutes.*

HOw to make this Line, was ſhewn by making the laſt. And if your Line of equal parts be divided into 100, or as they be reckoned 1000, you may omit the laſt Figure of the Number: But if you number the Scale to 2000, as the Tables are made, then if you would ſet off the Sine of 30 deg. the Parts anſwering thereunto are *1699*; therefore take off your Scale of equal parts with your Compaſſes 1699, and it will reach from the beginning to 30 deg. on the Line of Sines.

So I hope you underſtand how to do the reſt, it being made ſo plain and eaſy for the meaneſt Capacity.

A Table

A Table for the Division of the Artificial Sines on the Ruler.

Minutes.	Deg. Sine. 0	Deg. Sine. 1	Deg. Sine. 2	Deg. Sine. 3	Deg. Sine. 4	Deg. Sine. 5	Deg. Sine. 6	Deg. Sine. 7	Deg. Sine. 8	Deg. Sine. 9	Deg. Sine. 10
0	00	242	543	719	843	940	1019	1086	1143	1194	1240
10	46	309	577	742	861	954	1031	1096	1152	1202	1247
20	76	367	610	764	878	968	1043	1106	1161	1210	1254
30	94	418	640	786	895	981	1054	1116	1170	1218	1261
40	06	464	668	806	910	994	1065	1125	1178	1225	1267
50	163	505	694	825	926	1007	1075	1134	1186	1232	1274
Min.	11	12	13	14	15	16	17	18	19	20	21
0	1280	1318	1352	1384	1413	1440	1466	1490	1513	1534	1554
10	1287	1323	1357	1389	1418	1445	1470	1494	1516	1537	1558
20	1293	1329	1363	1394	1422	1449	1474	1498	1520	1540	1561
30	1300	1335	1368	1398	1427	1453	1478	1501	1523	1544	1564
40	1306	1341	1373	1403	1431	1457	1482	1505	1527	1548	1567
50	1312	1346	1378	1408	1436	1462	1486	1509	1530	1551	1570
Min.	22	23	24	25	26	27	28	29	30	31	32
0	1573	1592	1609	1626	1642	1657	1672	1685	1699	1712	1724
10	1577	1595	1612	1629	1644	1659	1674	1688			
20	1580	1598	1614	1631	1647	1662	1676	1690	1703	1716	1728
30	1583	1601	1618	1634	1649	1664	1679	1692			
40	1586	1603	1620	1637	1652	1667	1681	1694	1708	1720	1732
50	1589	1606	1623	1639	1654	1669	1683	1697			
Min.	33	34	35	36	37	38	39	40	41	42	43
0	1736	1747	1758	1769	1779	1789	1799	1808	1817	1825	1834
20	1740	1751	1762	1773	1783	1792	1802				
40	1744	1755	1766	1776	1786	1796	1805				
Min.	44	45	46	47	48	49	50	51	52	53	54
0	1842	1849	1857	1864	1871	1878	1884	1890	1896	1902	1908
Min.	55	56	57	58	59	60	61	62	63	64	65
0	1913	1918	1923	:928	1933	1937	1942	1946	1950	1954	1957
Min.	66	67	68	69	70	71	72	73	74	75	76
0	1961	1964	1967	1970	1973	1976	1978	1980	1983	1985	1987
Min.	77	78	79	80	81	82	83	84	85		90
0	1988	1990	1992	1993	1995	1996	1997	1998	1998		2000

V. *To make a Meridian Line according to the true Sea-Chart, or* Wright's *Projection.*

THis Line is made out of the Table of Meridian Parts, in *Book* 4. *Chap.* 7. which is to every 10 minutes of Latitude, nearer we have no Charts or Plots made, which I have as yet seen; but they may be made by Mr. *Wright*'s Tables to every *Minute*, if any Person will be so curious.

For the Graduating this Line in the Scale, you must note the Number answering to the first Degree is 200; therefore divide the Degrees of the Equinoctial into 20 equal parts, which stand for 200 the Number of your Table. *For Example.*

Suppose you would make the first 10 Deg. from the Æquator, towards either of the Poles on the Scale; the Number answering 10 Deg. is 20,1, (omitting the last Figure 0) you may take out of the Line of Longitude (which are the equal Parts of the same Line by which you made all the rest) 20,1 Parts, and lay that distance from the beginning for 10 Deg. and for 20 Deg. 40,8; and for 30 Deg. 62,9; and so of the rest.

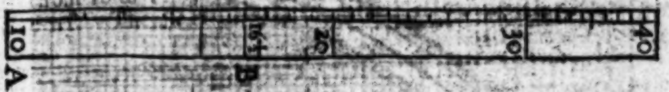
But

But if you are to make a particular Line, you must take the difference of the deg. and min. as shall be shewn in the Treatise of making a general and particular Sea-Chart, according to Mr. *Wright*'s Projection. There is demonstrated and shewn the making of *Mercator*'s Scale, to measure the distance in any Parallel of Latitude in the true Sea-Chart.

VI. *How to divide the Scale of Reduction.*

THis Scale is part of a Line of Numbers, twice as large as the Line of Numbers on the Mathematical Scale, beginning at 10 and proceeding to 40; and may be made by the former Table for the Division of the Line of Numbers.

Provide a Scale in which the Equal Parts are twice as large, as those by which you divided the former Line of Numbers, and then the Numbers in the Table; beginning at 10 and ending at 40, shall give the distances to divide the Scale of Reduction. As for instance, against 11 stands 41, therefore 41, such Parts whereof your Scale contains 1000, shall reach from 10 to 11, and 79 from 10 to 12, 114 from 10 to 13; and so of the rest. The use of this Scale shall be shewn in the fifth Book.



CHAP. V. *A Table for the Division of the Artificial Rhomb, or Points Halves, and Quarters on the Traverse Scale.*

THe Use of this Table is easily understood: The first Column is the Points in one quarter of the Compass, and the second their Names in the whole; the third the deg. answering to each quarter of a Point in the Quadrant; the fourth the Sines and Equal Parts answering thereunto; the fifth the Points for the Tangents; the sixth the Tangents answering to each Quarter Point.

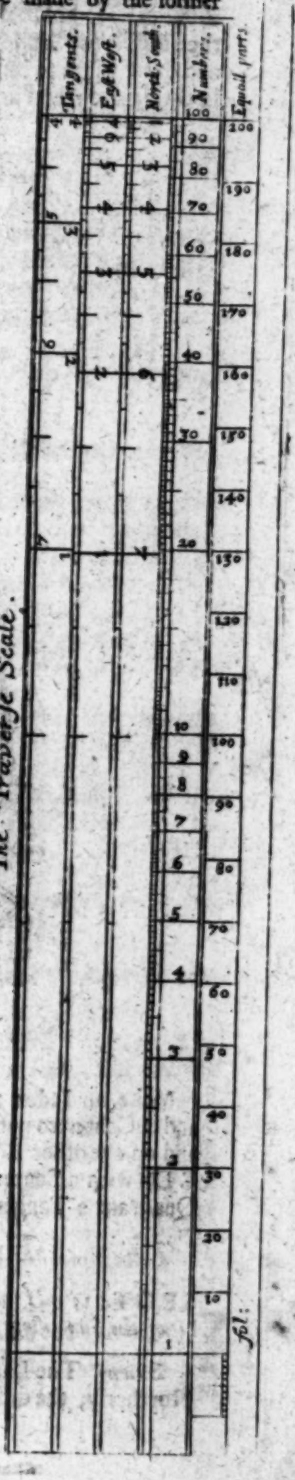
Points	Nor. Sou.	D. M.	Sine Rh.		Tan. Rh.
	N. b. E.	2.48	683		689
	S. b. E.	5.37	990		982
	S. b. W.	8.25	1166		1177
1	N. b. W.	11.15	1290	1.2	1298
	N. N. E.	14. 4	1385		1398
	S. S. E.	16.52	1462		1481
	S. S. W.	19.41	1527		1589
2	N. N. W.	22.30	1582	2.6	1617
	N. E. b. N.	25.18	1630		1673
	S. E. b. S.	28. 7	1673		1727
	S. W. b. S.	30.56	1710		1777
3	N. W. b. N.	33.45	1744	3.5	1824
	N. E.	36.33	1774		1870
	S. E.	39.22	1802		1944
	N. W.	42.11	1827		1957
4	S. W.	45.00	1849	4	2000
	N. E. b. E.	47.48	1869		
	S. E. b. E.	50.37	1890		
	S. W. b. W.	53.26	1904		
5	N. W. b. W.	56,15	1919		
	E. N. E.	59. 3	1933		
	E. S. E.	61.52	1945		
	W. S. W.	64 41	1956		
6	W. N. W.	67.30	1965		
	E. b. N.	70.18	1973		
	E. b. S.	73. 7	1989		
	W. b. S.	75.56	1986		
7	W. b. N.	78 45	991		
	East	81.33	1995		
	and	84.22	1997		
	West.	7.11	1999		
8		90.00	2000		

The Description of the Traverse-Scale.

This Scale is made by the foregoing Table; only the Line of Sines is there but once, and here the parts answering each Quarter, are twice put down, or in two Lines marked with N. S. which stand for northing and southing, and E. W. signifies Easting and Westing. The first is the Sine, second is the Sine Complement of the Angle that any Point or Quarter maketh with the Meridian.

Exam. Suppose you were to set the first and seventh Rhomb or Artificial Point on the Sines, which is 11 deg. 15 min. the equal parts answering thereunto, is 1290; therefore take 129 off your Scale of equal parts, and lay it from the beginning upwards, and you have by that distance the first and seventh Rhomb of your Scale. In like manner do for any other of the *Points* and *Quarters* by these Numbers, until you have finished the Scale; and when you have done, you have an Instrument the most easie, ready, and necessary that I know of, for the working of a Traverse, which shall be shewn in Sailing by the Plain Chart, in the Fourth Book. On the back side of this Scale you may set a Line of Chords, Equal Parts, and Points, for the ready protraction of Angles.

The Traverse Scale.

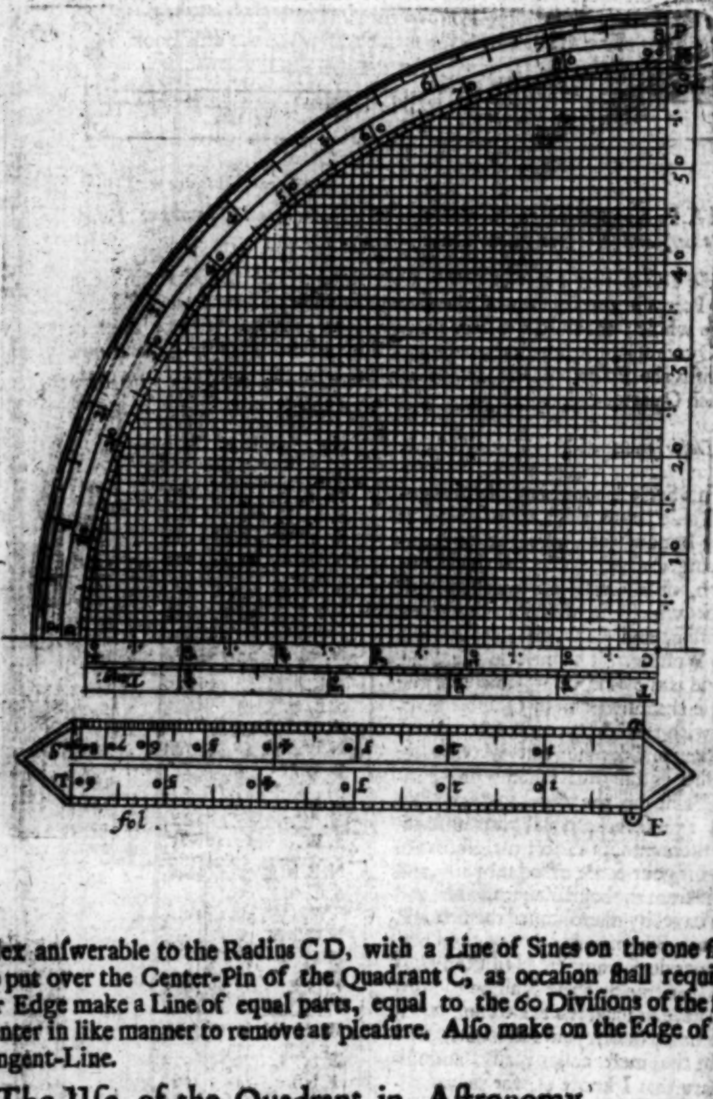


CHAP.

CHAP. VI.

How to make a Quadrant which will resolve many Questions in Astronomy, by the help of an Index; and also very useful in Navigation.

AFter you have made choice of the Radius of your Quadrant C D, draw the Margin, to hold the deg. of the Quadrant and the Figures, Points, and Quarters; then divide the Semidiamiter or side of the Quadrant C D and C M into 60 equal parts, and draw Lines to each of the Divisions, parallel to the Sides C D and C M, as you see in the Figure: and at every 5 make a Point, for the ready numbering of the Divisions.



Make an Index answerable to the Radius C D, with a Line of Sines on the one side and a Center to put over the Center-Pin of the Quadrant C, as occasion shall require and on the other Edge make a Line of equal parts, equal to the 60 Divisions of the side C D, with a Center in like manner to remove at pleasure. Also make on the Edge of the Quadrant a Tangent-Line.

The Use of the Quadrant in Astronomy.

SECT. 1. *Having the Latitude of the Place and the Sun's Declination, to find the Time of the Sun-rising and setting.*

Examp. The Latitude of 51 deg. 30 min. Northward, and the Declination 20 deg. Northerly, the difference of Ascension will be found thus:

First

First, Lay the Center at E of the Index, over the Brass Pin in the Center of the Quadrant at C, and lay the Edge of the Index E L to the Latitude of the Place on the Arch D M; and from the Tangent-Line on the Edge of the Quadrant take 20 deg. the Sun's Declination; and lay that distance from the Center at C towards D, at that distance run with your Eye along the Parallel-Lines, and mark where it intersects the Edge of the Index, and likewise observe where the Index cuts those Lines that are parallel to C D; there follow that Parallel-Line to the Arch, and the deg. from D to that Parallel-Line will be 27 deg. $\frac{1}{4}$, the difference of Ascension. The deg. resolved into hours and min. is 1 hour 49 min. which subtracted from 6, is 4 of the Clock and 11 min. for the Sun-rising in the Morning, and added to 6, gives 7 of the Clock 49 min. his setting in the Evening.

SECT. 2. *Having the distance of the Sun from the next Æquinoctial Point, To find his Declin.*

Examp. The Sun being either in 29 deg of *Taurus*, or 1 deg. of *Aquarius*, or 1 deg. of *Leo*, or 29 deg. of *Scorpio*, that is 59 deg. from the next Æquinoctial Point, To find his Declination, do thus; put the Center of the Line of Sines on the Pin, and lay the Edge of the Index to 23 deg. $\frac{1}{2}$, the Sun's greatest Declination, reckoned from M towards D; then count the Sun's distance 59 deg. on the Line of Sines on the Index, and putting one foot of your Compasses to that deg. with the other take the nearest distance to the side C M, and apply that distance in the Line of Sines on the Index, from the Center, and the other foot will reach to 20 deg. the Declination required.

SECT. 3. *Having the Latitude of the Place, and the Declination of the Sun, To find the Sun's true Amplitude from the East and West.*

Examp. Suppose the Latitude be 13 deg. Northerly, and the Sun's Declination 20 deg North, the Sun's Amplitude is required.

Put the Center of the Side of the Index on which is the Line of Sines on the Center of the Quadrant, and lay the Edge to 13 deg. which is the Latitude, then count from M 20 deg. of Declination, and carry your Eye along the Parallel-Lines from that deg. of the Arch, and mark what deg. it cuts of the Index on the Line of Sines as in this Question it doth 20 deg $\frac{1}{2}$ Northerly, and that is the Amplitude required.

Secondly, Suppose you were about the *Capes* of *Virginia*, in Latitude 37 deg. $\frac{1}{4}$, and Declination 10 deg. Southerly, if you work as before directed, you will find the Amplitude to be 12 deg. $\frac{1}{2}$ Southerly.

Note. The Amplitude is the distance of the Rising or Setting of the Sun or Stars from the true East and West Points of the Horizon. As for the foregoing Example; in the Latitude of 13 deg. the Sun or any Star having North Declination 20 deg. they will rise 20 deg. $\frac{1}{2}$ to the Northward of the East, and set 20 deg. $\frac{1}{2}$ to the Northward of the West. But if the Declination had been 20 deg. South, then they would have risen 20 deg. $\frac{1}{2}$ to the Southward of the East, and set 20 deg. $\frac{1}{2}$ to the Southward of the West. And so if you bring these deg. into Points and Quarters, and use the Variation-Compass upon the Instrument for the Tides, in the First Book, you may readily rectifie the Compass you Steer by,

SECT. 4. *The Use of the Quadrant and Variation-Compass, on the Instrument for the shifting of Tides.*

The Variation-Compass contains two Parts or Rundles, being the two uppermost in the aforesaid Instrument, moving one upon the other, as there you see. The biggest of the two uppermost Rundles may represent the Compass you Steer the Ship by, which is subject to Variation; and the upper Compass represents the true Compass that never varieth, whereby you have a necessary Instrument to rectifie the Compass by the help of this Quadrant. Admit I am in the Latitude of 27 deg. Northerly, and Declination 20 deg. North, and I observe the Sun's Rising to be East and by North, by the Compass; the Variation in that Latitude is required. The Sun having North-Declination, and in the Latitude of 27 deg. North, the Sun will rise from the East Northerly 22 deg. $\frac{1}{4}$, which is E. N. E. But by the Compass, the Sun did rise at E. b. N. Therefore it plainly appears that there is a Point Variation. Therefore on the Instrument aforesaid, you must always bring the true Point of Rising and Setting on the upper Rundle, to the Point of Rising and Setting by the Compass, on the middle Rundle; and being set in this Position,

you will find the E. b. N. of the Compass to be the true E. N. E. and the W. b. N. to be the true W. and the N. b. E. to be the true N. and the S. b. W. to be the true S. and S. E. ¼ Point Southerly, to be true S. E. b. E. ¼ Southerly ; and the South ½ East, to be the true S. b. E. ½ E. And so you may do in all other Observations.

SECT. 5. *Several Problems of Navigation wrought by the Quadrant.*

PROB. 1. *To find the Number of Miles or Minutes of the Equinoctial answering to any Degree of Longitude, in any Degree of Latitude.*

In Sailing by the Compass, the Course sometimes is upon a great Circle, sometime upon a parallel to the Æquator, but most commonly upon a Spiral Line, winding towards one of the Poles, but never passing through them.

Deg.	Min.	Miles.
00	00	60
18	12	57
25	15	54
31	48	51
36	52	48
41	25	45
45	34	42
49	28	39
53	08	36
56	58	33
60	00	30
63	01	27
66	25	24
69	30	21
72	32	18
75	31	15
78	28	12
81	23	09
84	15	06
87	08	03

If the Course hold upon a great Circle, it is either North or South under some Meridian ; or East or West under the Æquator.

But if the Course be East or West, in any of the Parallels to the Æquator, then

As Radius is to 60 Miles, or 20 Leagues, the measure of one deg. of the Æquator :
So is the Sine-Complement of the Latitude, to the Miles or Leagues in one deg. of Longitude in that of Latitude.

But if you would know by the foregoing Quadrant the miles answering to a deg. of Longitude in each Parallel of Latitude, it is thus :

Set the Ear E on the Center-Pin, and reckon the deg. of Latitude from D : to which set the Edge of the Index, and note the Parallel-Line that meets with the deg. of Latitude ; carry your Eye on that Parallel till it meet with the Side CD, and there it shews you the Number of miles answering to a deg. in that Latitude.

Examp. In the Latitude of 18 deg. 12 min. set the Index to 18 deg. ⅕ from D, and the Parallel-Line meeting that deg. follow with your Eye (or a Pin) to the Edge, and you will find it to be 57 miles ; so in the Latitude of 31 deg. 48 min. you will find 51 miles ; as in the Table annexed.

PROB. 2. *To find how many Leagues do alter one deg. of Latitude, on every Point and Quarter Point of the Compass.*

Rhombs.	Number of League. L.	P.	Rhombs.	Number of League. L.	P.
¼	20	02	4¼	29	78
½	20	10	4½	31	52
¾	20	22	4¾	33	57
1	20	39	5	36	00
1¼	20	62	5¼	38	90
1½	20	90	5½	42	43
1¾	21	24	5¾	36	76
2	21	65	6	52	36
2¼	22	12	5¼	59	37
2½	22	68	6½	68	90
2¾	23	32	6¾	82	31
3	24	05	7	102	52
3¼	24	90	7¼	136	30
3½	25	87	7½	205	14
3¾	26	99	7¾	400	6c
4	28	08	8	*Infinite.*	

As the Sine-Complement of the Rhomb from the Meridian, is to 20 Leagues :

So is the Radius to the Leagues answering to one deg. upon the Rhomb.

By which Proportion was made this Table annexed.

Suppose by the Quadrant it were required to answer this Question :

Sailing N. N. E. from 40 deg. of North Latitude, *How many Leagues shall the Ship run before she can come to 41 deg. because this is the second Rhomb from the Meridian.*

Therefore set the Side of the Index E L to the second Point from the Meridian, and reckon from C 20 Leagues towards D, and with your Eye (or a Pin) follow the Parallel-Line to the Index, and you will find it cut 21⅔ Leagues, the Number of Leagues you must Sail before you can raise 1 deg. of Latitude.

PROB. 3. *By the Rhomb, and Distance, To find the difference of Latitude.*

The distance upon the Rhomb 21 Leagues ½ the Rhomb

N.

N. N. E. therefore set the Index to the second Point, and count 21 Leagues; thereon, and run your Eye up the Parallel-Line you there meet with, and reckon the Leagues from the Center C to that Line, and you will find it 20 Leagues, which is the difference of Latitude required.

PROB. 4. *By the Rhomb, and both Latitudes, To find the distance in the Rhomb.*

Suppose the one Place given were in the Latitude 40 deg. the second Place in the Latitude 41 deg. and the Course 2 Points from the Meridian. Set the Index to the Rhomb, and account 20 Leagues, which is the difference of Latitude, from C towards D, and carry your Eye on that Parallel to the Index; and there it will cut the distance upon the Rhomb, which in this Question, is 21½ Leagues.

PROB. 5. *By the distance and both Latitudes, To find the Rhomb.*

Suppose one Place to be in the Latitude of 40 deg. and the second 20 Leagues further Northward, and the distance was 21½ Leagues; to find the Course. From the Center C reckon 20 Leagues towards D, follow that Parallel, and set the distance on the Index to that Parallel, and look in the Arch of the Quadrant, and you will find the Rhomb two Points from the North.

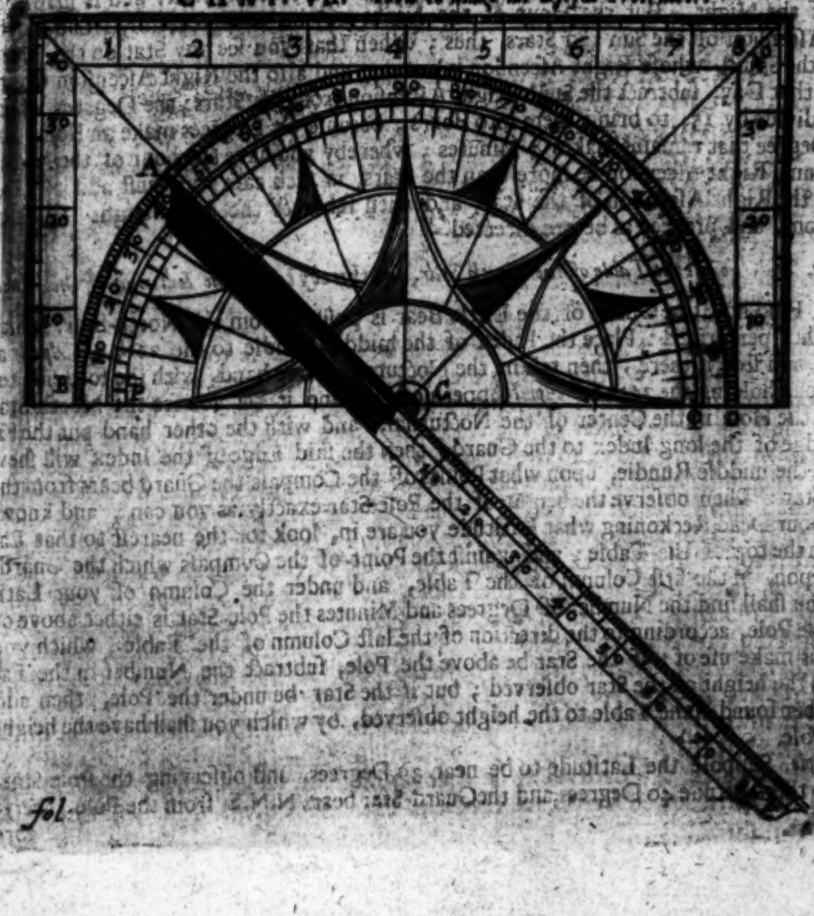
PROB. 6. *By the difference of Meridians, and Latitude of both Places, To find the Rhomb.*

Suppose one place to be in the Latitude of 40 deg. and the other in 41 deg. and the departure 8 Leagues ¼. First, Count from C towards D the difference of Latitude 20 Leagues, on that Parallel count 8 Leagues ¼, to that Point put the Index, and in the Arch you will find the Course to be 2 Points from the Meridian.

PROB. 7. *By the Rhomb and both Latitudes, To find the departure from the Meridian.*

Let the Rhomb be 2 Points from the Meridian, the one Latitude given 40 deg. the other Latitude 41 deg. Set the Index to the second Point from the Meridian, and count 20 Leagues the difference of Latitude from C towards D, upon that Parallel reckon the departure to the Index, which you will find in this Question 8 Leagues.

CHAP. VII. *How to make an Useful Protractor.*



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This Instrument is best to be made in Brass. On the Center C draw the Semicircle B O, and divide it into twice 90, or 180 Degrees, as you see in the Figure; and let the sixteen Points of the Compass with the Quarter-Points be set in the inward Circle P φ, and let the Index A E be two Diameters and ½ long, and divided from the Center to the end of the Index into 100 equal Parts, which are accounted sometimes Leagues, and sometimes Perches; or any other denomination, according as you have occasion to use it. Let the Index be fastned to the Center with a Brass Rivet, and through the midst of the Rivet there must be a hole drill'd; through which you must put a Pin or Needle, and divide the Edges into equal Parts.

And now you have a necessary Instrument, which will protract any Traverse or Draught of Land upon Paper, with as much speed as any Instrument I ever yet knew, the use whereof shall be shewn in this Treatise.

CHAP. VIII. *The Projection of the Nocturnal.*

IT consists, as you see, of three Parts. The greatest or Handle-part hath on it two Circles divided: On the first or outmost is the Ecliptick, divided into 12 equal Parts, in which is put the 12 Signs; and each of those 12 Parts is divided into 30 equal Parts, or Degrees, in each Sign numbred with 10, 20, 30, as you see in the Figure. The inward Circle is the 12 Months of the Year, and the Days in each Month equally divided, and numbred with 10, 20, 30. The middle Rundle is equally divided into twice 12 Hours; and without that is a Circle divided into 32 Points of the Mariner's Compass, with the Quarter-Points. The upper part is an Index, of a convenient length; all three being fastned with a piece of Brass, so that the Center is an hole, through which you are to see the North Star. You may make it of good dry Box.

The use of the Nocturnal. Let the Tooth or Index of the middle Circle be set to the Day of the Month, and it will cut in the outward Circle the Sun's place in the Ecliptick. Then hold the Instrument upward a pretty distance from you, and look through the hole in the Center, to the North Star, turning the long Index upwards or downwards, until you see the brightest of the Guards of the Little Bear, upon the Edge that comes from the Center. Then look on the Hour-Circle by the Edge of the Index, and it shews the Hour of the Night. But the Hour of the Night may be more certainly found by the Right Ascension of the Sun and Stars, thus; When you see any Star on the Meridian in the South, whose Right Ascension is known, and also the Right Ascension of the Sun for that Day, subtract the Sun's Right Ascension from it; the Degrees which remain divide by 15, to bring them into Hours; because 15 Degrees make an Hour, and every Degree that remains makes 4 Minutes; which gives you the hour of the Night. If the Sun's Right Ascension be more than the Stars, in such case you must add 360 Degrees to the Right Ascension of the Star, and then subtract the Sun's Right Ascension there-from, and proceed as before directed.

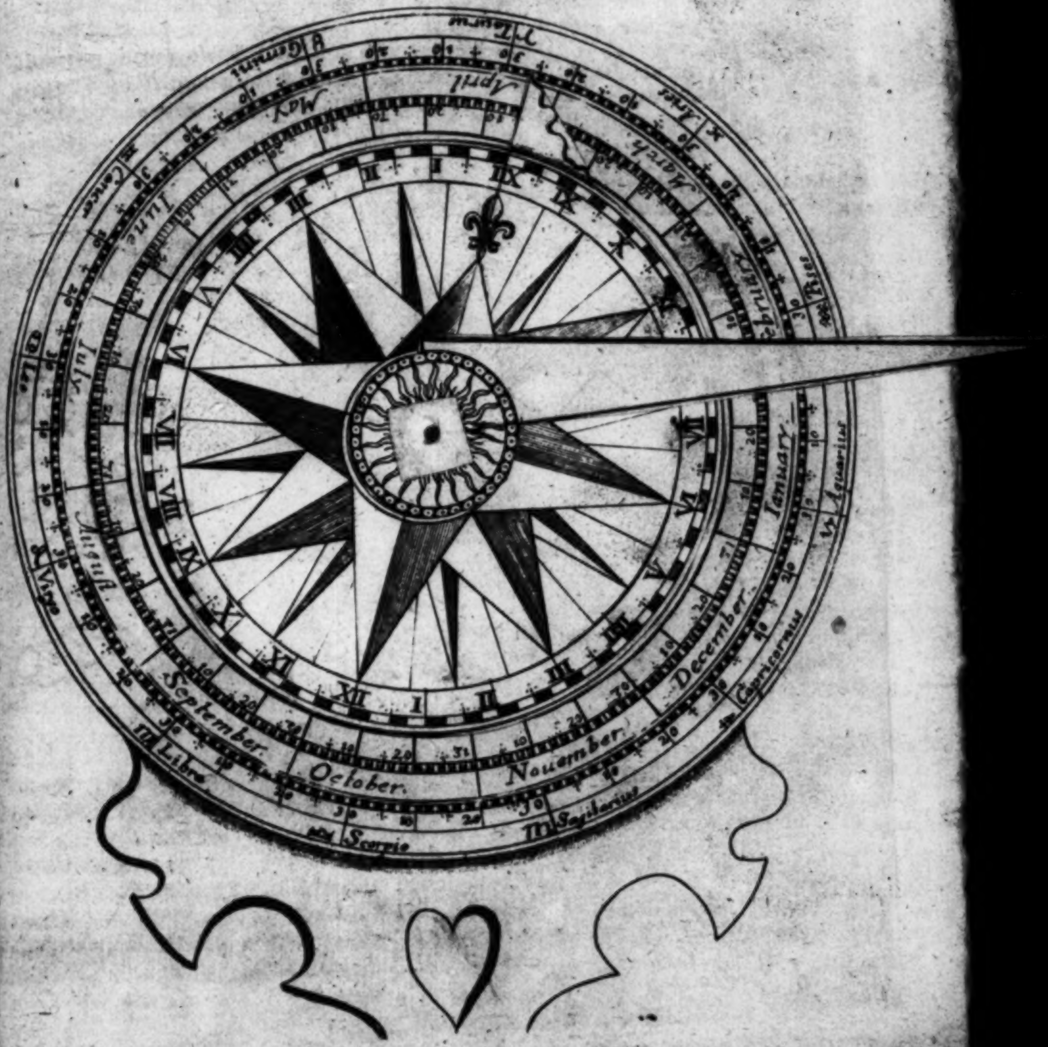
Here place the Nocturnal for the Pole-Star.

CHAP. IX. *To use the Table of the North Star, and thereby to find the Latitude of the Place.*

FIrst, Find how the Guard of the Little Bear is posited from the North-Star, which is thus performed: Place the Index of the middle Rundle to the 26th of *April* at the top, and keep it there; then taking the Nocturnal in one hand, with the fore-side towards you, holding the 26th of *April* uppermost, incline it till you see the North-Star through the Hole in the Center of the Nocturnal, and with the other hand put the Fiducial-edge of the long Index to the Guard; then the said Edge of the Index will shew you, on the middle Rundle, upon what Points of the Compass the Guard bears from the North-Star: Then observe the height of the Pole-Star exactly as you can; and knowing by your Dead Reckoning what Latitude you are in, look for the nearest to that Latitude in the top of the Table; and against the Point of the Compass which the Guard-Star is upon, in the first Column of the Table, and under the Column of your Latitude, you shall find the Number of Degrees and Minutes the Pole-Star is either above or below the Pole, according to the direction of the last Column of the Table; which you must thus make use of: If the Star be above the Pole, subtract the Number in the Table from the height of the Star observed; but if the Star be under the Pole, then add the number found in the Table to the height observed, by which you shall have the height of the Pole.

Example. Suppose the Latitude to be near 30 Degrees, and observing the Pole-Star, you find the Altitude 30 Degrees, and the Guard-Star bears N. N. E. from the Pole; there-

A : Nocturnal



Taurus
Gemini
Cancer
Leo
Virgo
Libra
Scorpio
Sagitarius
Capricornus
Aquarius
Aries
April
May
Iune
Iuly
August
September.
October.
Nouember.
December.
Ianuary.
March.

fore look for N. N. E. in the first Column, and right under 40 Degrees of Latitude in the same Line with N. N. E. you will find the Declination to be 1 Deg. 30 Min. subtract that from 40 Deg. the Altitude observed leaves the true Latitude 38 Deg. 30 Min. But if the Guard-Star had been S.S.W. then the Pole-Star had been 1 Deg. 33 Min. under the Pole; which being added to the Altitude observed 40 Deg. the Latitude would have been exactly 41 Deg. 33 Min. So the Star's Altitude by observation being 55 Deg. the Guard bearing S.E.b.S. the Declination against that Point is 2 Deg. 30 Min. which added to 55, makes 57 Deg. 30 Min. for the Latitude: but if you estimate Latitude had been near 50, and the Guard bears from the Pole N.W.b.N. the Declination against that point is 2 Deg. 30 Min. subtracted from 55 Degrees, the Altitude observed, there remains 52 Deg. 30 min. the Latitude of the Place.

A Table of the North Star's Altitude in these several Latitudes.

	The Points of the Compass.	0		20		30		40		50		60		70		
		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	
If the former of the Guards be ascending from the North or lower part of the Meridian.	North.	2	10	2	10	2	10	2	09	2	09	2	00	2	07	*Above the Pole.*
	N. b. E.	1	53	1	53	1	53	1	52	1	52	1	51	1	49	
	N. N. E.	1	31	1	31	1	30	1	30	1	29	1	28	1	25	
	N. E. b. N.	1	06	1	05	1	04	1	03	1	02	0	01	0	58	
	N. E.	0	39	0	38	0	37	0	36	0	35	0	33	0	30	
	N. E. b. E.	0	10	0	09	0	08	0	07	0	06	0	04	0	01	
	E. N. E.	0	18	0	19	0	20	0	21	0	22	0	23	0	26	*Under the Pole.*
	E. b. N.	0	49	0	50	0	50	0	51	0	52	0	53	0	56	
	East.	1	15	1	15	1	16	1	17	1	18	1	19	1	21	
	E. b. S.	1	38	1	39	1	39	1	40	1	41	1	42	1	44	
	E. S. E.	2	00	2	00	2	00	2	00	2	00	2	01	2	02	
	S. E. b. E.	2	15	2	15	2	15	2	15	2	16	2	16	2	16	
	S. E.	2	25	2	25	2	25	2	25	2	25	2	25	2	25	
	S. E. b. S.	2	30	2	30	2	30	2	30	2	30	2	30	2	30	
	S. S. E.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	S. b. E.	2	22	2	22	2	22	2	22	2	22	2	22	2	22	
If the former of the Guards be descending from the South or upper part of the Meridian.	South.	2	10	2	10	2	10	2	11	2	11	2	11	2	12	*Under the Pole.*
	S. b. W.	1	58	1	53	1	54	1	53	1	55	1	55	1	57	
	S. S. W.	1	31	1	32	1	32	1	33	1	34	1	35	1	38	
	S. W. b. S.	1	07	1	07	1	08	1	10	1	11	1	13	1	13	
	S. W.	0	39	0	40	0	41	0	40	0	43	0	44	0	47	
	S. W. b. W.	0	10	0	11	0	12	0	13	0	14	0	16	0	19	
	W. S. W.	0	19	0	19	0	17	0	16	0	15	0	13	0	10	*Above the Pole.*
	W. b. S.	0	48	0	47	0	46	0	45	0	44	0	43	0	43	
	West.	1	15	1	14	1	13	1	12	1	11	1	10	1	08	
	W. b. N.	1	39	1	39	1	38	1	37	1	36	1	35	1	33	
	W. N. W.	2	00	1	59	1	59	1	58	1	58	1	57	1	56	
	N. W. b. W.	2	15	2	15	2	14	2	14	2	14	2	13	2	12	
	N. W.	2	25	2	25	2	25	2	25	2	24	2	24	2	24	
	N. W. b. N.	2	30	2	30	2	30	2	30	2	30	2	30	2	30	
	N. N. W.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	N. b. W.	2	22	2	22	2	22	2	22	2	22	2	21	2	21	

CHAP. X. *To make an Useful Instrument of the Stars, and by it to know when any of those Stars will come to the Meridian, at any time of the Year.*

THis Instrument consisteth of two parts, which are two Rundles; it may be made on the back-side of the foregoing Nocturnal: On the greater Rundle are three Circles divided; the outermost is the 12 Months of the Year, beginning the 10th of *March*, the day the Sun enters into *Aries*; and the Days equally divided according to the Number of Days in each Month. The second Circle is equally divided into 24 Hours. And the third and inward Circle represents the Equinoctial, divided into 360 Degrees; by it is accounted the Right Ascension of these 31 Stars in the Table following.

A Table of the Longitude, Latitude, Right Ascensions, and Declinations, of 31 of the most Notable Fixed Stars; calculated and rectified for the Year 1671.

	Longitude.			*Latitude.*			*Right Ascen.*		*Declination.*		*Nor. Sout.*	
In the Whale's Tail, the Brightest.	27	56	♓	20	47	S	06	45	19	48	S	2
The Bright Star in the South Foot of Andromeda.	09	39	♉	27	46	N	25	57	40	44	N	2
The Bright Star in the Right Side of Perseus.	27	17	♉	30	05	N	44	16	48	36	N	2
The Brightest of the Seven Stars or Pleiades.	25	24	♉	04	00	N	52	00	23	03	N	3
The South Eye of the Bull, Aldebaran.	05	12	♊	05	31	S	64	17	15	48	N	1
The Bright Star in the left Foot of Orion, Rigel.	12	17	♊	31	11	S	74	44	08	37	S	1
Orion's *Right Shoulder.*	24	12	♊	16	06	S	84	23	07	18	N	1
The glittering Star in the Mouth of the great Dog.	09	35	♋	39	30	S	97	42	16	14	S	1
The little Dog's Thigh, Procyon.	21	18	♋	15	57	S	110	34	06	03	N	2
In the South Arm of the Crab.	09	03	♌	05	08	S	130	07	13	48	N	3
The Bright Star called the Heart of the Hydra.	22	45	♌	22	24	N	137	54	07	15	S	1
The Lion's Heart, Regulus.	25	17	♌	00	26	N	147	43	13	33	N	1
The lower of the Pointers.	14	43	♌	45	03	N	160	18	58	08	N	2
The Northern Pointer.	10	34	♌	49	40	N	160	48	63	32	N	2
The Lion's Tail.	17	03	♍	12	18	N	173	04	15	25	N	1
The first in the Tail of the great Bear.	04	10	♍	54	18	N	189	53	57	47	N	2
The second in the Tail.	10	56	♍	56	22	N	297	37	56	41	N	2
The last in the Tail.	22	12	♍	54	25	N	203	37	51	00	N	2
In the Skirt of Boots his Garment, Arcturus.	19	39	♎	31	02	N	210	13	20	58	N	1
The South Balance of Libra.	10	31	♏	00	26	N	218	13	14	37	S	2
The Brightest of the Guards.	08	16	♌	72	51	N	222	45	75	36	N	2
The Scorpion's Heart, Antares.	05	13	♐	04	27	S	242	23	25	37	S	1
Hercules *his Head.*	11	31	♐	37	23	N	254	12	14	50	N	3
The Bright Star of Lyra.	10	43	♑	61	47	N	276	27	38	30	N	1
The Swan's Bill.	26	44	♑	49	02	N	289	23	27	18	N	3
The Eagle's Heart.	27	09	♑	29	21	N	293	41	08	03	N	2
The Dolphin's Tail.	09	32	♒	29	08	N	304	24	10	14	N	3
The Mouth of Pegasus.	27	22	♒	22	07	N	322	03	08	24	N	3
The Bright Star of Pegasus *Neck.*	11	39	♓	17	41	N	336	21	09	08	N	3
The first Star in the Wing of Pegasus, Marchab.	18	56	♓	19	26	N	342	07	13	28	N	2
Andromeda's *Head.*	09	47	♈	25	42	N	357	54	27	18	N	2

On the other Rundle or upper part, is placed the aforesaid Stars; and any other yo[u] may set thereon, if you follow this Rule. For Example, First set the Index to the 10[th] day of *March*, and stop it fast there, that it may not move, until you have placed the Star[s] on it which you intend. As suppose you would set the *Whale's Tail* on the Rundle; look in the foregoing Table, and you will find his Right Ascension 6 deg. 45 min. account 6 deg. ¾ on the Equinoctial Circle, and lay a Ruler from the Center over the 6 deg. 4[5] min. and draw the Line from the Center to the outward Edge of the upper Rundle, an[d] thereon set the Name of the Star, next to that the Declination of the Star, and the Letter S or N, representing South or North Declination. Take this Example more. Suppose you would set on the *Lion's Heart*: In the Tables I find his Right Ascension is 147 deg. 4[3] min. reckon that Number on the Equinoctial Circle, and draw the Line as before directed.

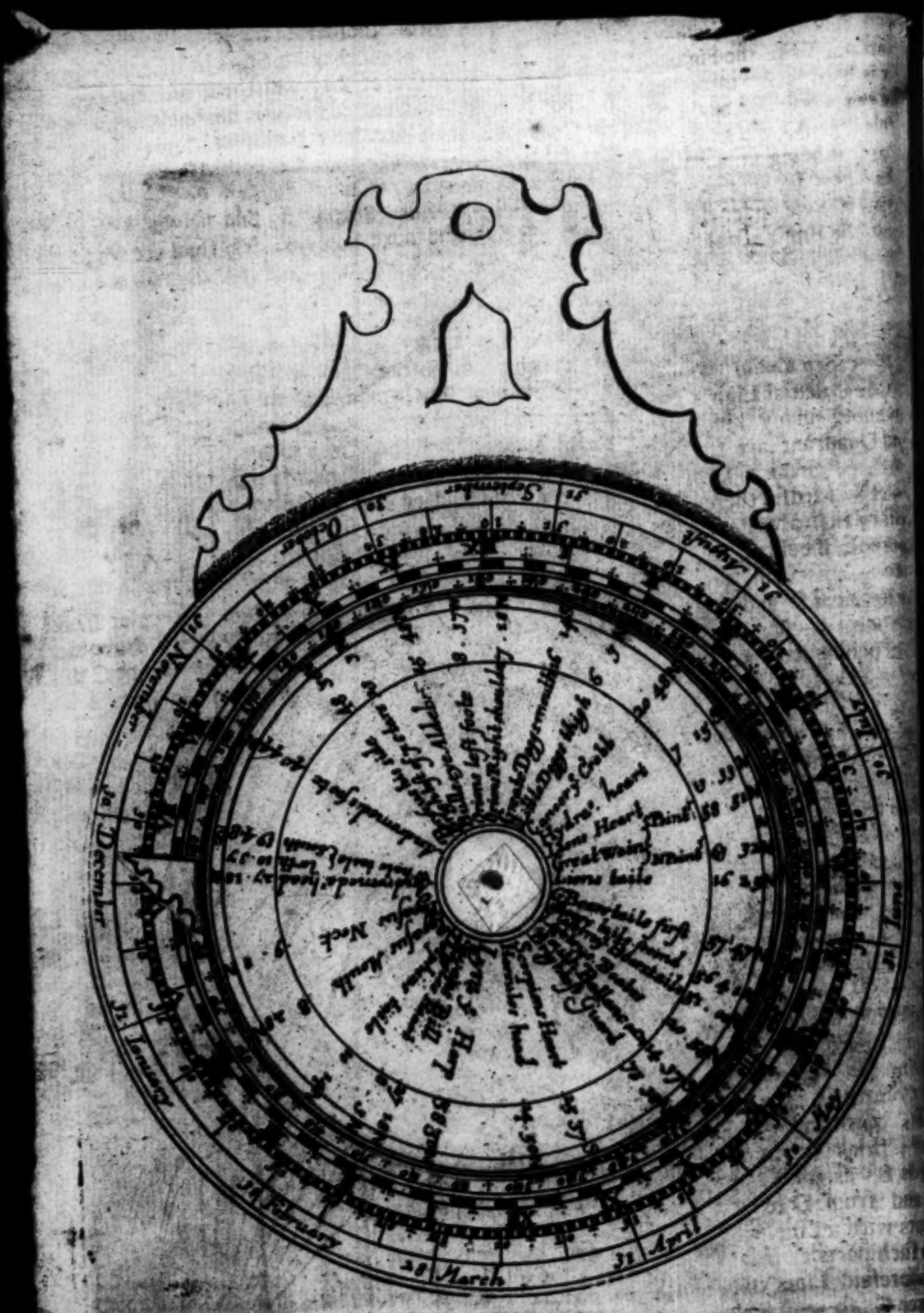
To know the Hour of the Night when any Star comes to the Meridian.

Set the Index of the upper Rundle to the Day of the Month, and right against the Sta[r] is the Hour of the Night, when the Star will be on the Meridian. For Example, Suppose you would know the Hour of the Night the *Bull's Eye* comes to the Meridian the 20*th* day of *October*: Set the Index to the Day, and right against the *Bull's Eye* is ½ of an Hour past 1, the time in the Morning that Star will be on the Meridian South. And in the same manner you may see the other Stars, at what Hours they come to the Meridian that Day and Night. For note the upper 12, is 12 at Noon, and the lower 12 is 12 at Night.

To know the Hour of the Night, by the Stars being on the Meridian.

Suppose it were required to know the Hour of the Night the 10*th* of *December*, th[e] brightest of the 7 Stars being on the Meridian in the South; Set the Index to the Day o[f] the Month, and right against the brightest of the 7 Stars, is half an Hour past 9 at Nigh[t], which is the Hour required.

CHA[P.]



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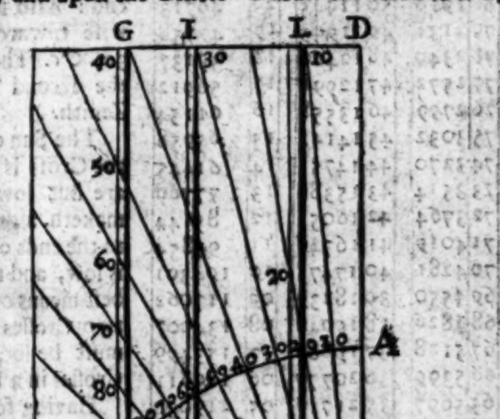
CHAP. XI. *Of the Crosiers.*

WHen the Mariners pass the Equinoctial Line towards the South, so that they cannot see the North Star, they make use of another Star, which is in the Constellation called the *Centaur*; which Star, with three other noble Stars in the same Constellation, make the Figure of a Cross, for which cause they call them the *Crosiers*. And it is held for certain, that when the Star A (which of all four is nearest the South Pole) is perpendicular to the Star B, then it is rightly situated for Observation. And because this Star A, which is called the *Cocks-foot*, is 28 deg. from the South Pole, it cometh to pass, it being situated as before-said, if we take the Meridian Altitude thereof, this will shew how far we are distant from the Equinoctial. For if the said height be 28½ deg. then are we under the Equinoctial: But if it be more than 28½ deg. then are we so much past the Equinoctial toward the South: And if it be less than 28½ deg. so much as it wanteth, are we to the North of the Equinoctial.

CHAP. XII. *How to make the Cross-Staff.*

THe Mariners Cross-Staff is that which by Astronomers is called *Radius Astronomicus*, by which we observe the Altitude of the Celestial Lights above the Horizon. Mathematicians have invented many kinds of Instruments, whereof the Cross-Staff and Quadrant are the most useful at Sea. It is not every man's work to make a Cross-Staff or other Instruments, for want of Practice needful thereunto; yet notwithstanding it is fit and necessary that a Master, his Mates, and Pilot, who have the use thereof, should at least know when it is well made. For to divide a Cross-Staff, you may prepare a flat Board of good dry Wood, fifteen or sixteen Inches broad, and about four Foot long: Paste it well with good Paper; draw along one side a Right Line, as in the next following Figure C A D; from the Point C draw a perpendicular Line upon A C, as C B, and upon the Center C draw the Arch A E B; being a Quadrant or fourth part of a Circle; divide that into two parts; the one half also, as A E, divide into 90 equal parts; first into three parts, and each of the same again into three; these parts into two, and each of the last into five: So the Arch A E shall then be divided into 90 parts. Then take a straight Ruler, lay the one end on the Point or Center C, the other upon each Point of the aforesaid several Divisions, and draw small Lines out of C, through each of the aforesaid Points or deg. of the Quadrant, as long as the Board will permit, as you may see in the Figure. Then take a pair of Compasses, the half length of the Cross that you would make for the Staff; prick it from the Point C towards B; as for Example, from C to F, and from D to G; joyn these two Points with a Line, as G F; and even into such parts as that Line is cut, by the aforesaid Lines coming out of the Center C, so must your Staff be divided, whether the Cross be longer or shorter, as appeareth by the Lines H I and K L, which are drawn for Crosses, the half length thereof is C H, or C K. If the aforesaid Quadrant be not well divided, or the Lines not well drawn,



the

the Staves being divided there-from will also be faulty. Therefore they may be divided more exactly in manner as followeth.

Prepare you a Staff, draw thereon a Right Line as long as your Staff, and take with a sharp pair of Compasses the half length of your Cross for which you desire to divide your Staff; prick it as often along the aforesaid Line as you can. Divide each of the lengths of the half Cross into 1000 equal parts. Then prick upon the Staff you would divide, from the Center-end, just half the length of the Cross; and make there a small thwart stroke. Off from thence prick for each deg. so many of the same parts as the Cross is divided in his half length, according to the Table here annexed for every deg. For 89 deg. you shall mark off from 90 the aforesaid thwart Stroke $17\frac{6}{10}$ for 86 deg. $72\frac{4}{10}$ for the 80 deg. $16\frac{8}{10}$ of those parts, and so of the rest. If you cannot divide the half Cross, by reason he is so little, into 1000, divide him into 100, and leave out the two last Figures, and that shall satisfie your desire: For 60 deg. take 73, and for 50 deg. 114, and for 80 deg. 19. parts, and so of the rest.

A Table for the Division of the Cross-Staff.

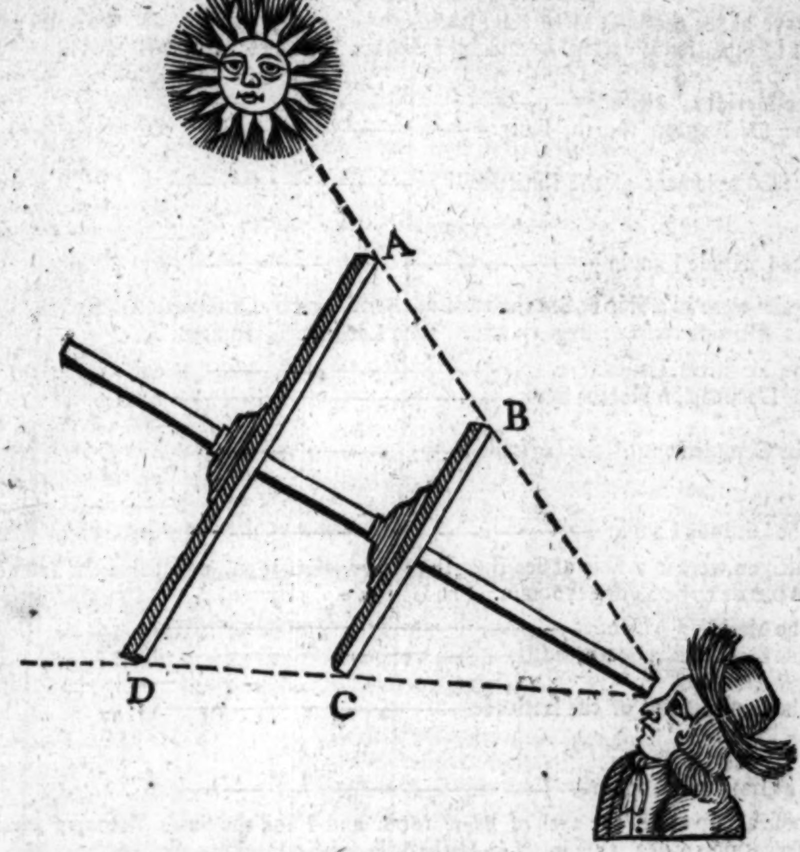
D	Parts	D.	Parts.	D.	Parts.
89	176	59	7675	29	28667
88	355	58	8040	28	30108
87	538	57	8418	27	31653
86	724	56	8807	26	33315
85	913	55	9210	25	35107
84	1106	54	9626	24	37046
83	1303	53	10057	23	39152
82	1504	52	10503	22	41445
81	1708	51	10965	21	43955
80	1918	50	11445	20	46713
79	2131	49	11943	19	49758
78	2349	48	12460	18	53137
77	2572	47	12998	17	56912
76	2799	46	13558	16	61154
75	3032	45	14142	15	65958
74	3270	44	14751	14	61445
73	3514	43	15386	13	77769
72	3764	42	16051	12	85144
71	4019	41	16746	11	93854
70	4281	40	17475	10	104301
69	4550	39	18239	09	117062
68	4826	38	19042	08	134007
67	5108	37	19887	07	153499
66	5399	36	20777	06	180811
65	5697	35	21716	05	219038
64	6003	34	22708	04	276332
63	6318	33	23759	03	371885
62	6643	32	24874	02	561810
61	6970	31	26059	01	1135886
60	7320	30	27321	00	*Infinite.*

CHAP. XIII. *How to use the Cross-Staff.*

SEt the end of Cross-Staff to the outside of the Eye, so that the end of the Staff come to stand right with the middle of the Sights. Then move the Cross from you or towards you, holding it upright, and winking with your other Eye, till that the upper end cut the Center of the Sun or Star, and the lower end cut the Horizon, the Cross then shall shew upon the side of the Staff belonging thereunto, the deg. of the Altitude of the Sun or Star. *Note*, The Staff is marked with two rows of Numbers, with 90 deg. next the Eye, and diminishing from 90 to 80, 70, 60, *&c.* towards the outmost end: Also from the Eye end they increase contrariwise towards the outmost end, as from 10 to 20, 30, *&c.* The first Number sheweth you the Altitude, the second Number the Sun's distance from the Zenith.

The Sun or Stars being high above the Horizon, the Cross is moved nearer the Eye than when they are but low and near the Horizon, and the Eye maketh a greater motion in looking up and down to the ends of the Cross, than when the Sun or Star is low, and therefore subject to a greater Error. The best means of all in my opinion is this; To try with two Crosses set upon the like deg. how the Staff must be set, that they may see the ends of the two Crosses in a Right Line one with the other.

Having found that, and then taking off one of the Crosses, and setting the Staff again, in the same manner as before, all Errors will be prevented, which by the lifting up or down of the Eye might any way happen. *Examp.* I desire to observe the Sun or any Star in the South: I make my Estimation, as near as I can, how high it shall be, or take the height of them a little before they shall come to the South, which I take to be 50 d. I set therefore the two Crosses each upon 50 deg. and the end of the Staff in the hollow of the Eye-bone, on the outside of the Eye, and move the end of the Staff higher or lower till I see the end of both the Crosses right one with the other, according as is shewn by these Lines A B and C D in the Foregoing Figure; and keeping in memory that standing of the Staff, I take off the one Cross, and set the Staff again in the aforesaid manner to the Eye, and observe the Altitude therewith, so avoiding the Error mentioned.



In taking the height of the Sun with the Cross-Staff, they use red or blue Glasses for the saving and preserving the Eyes; yet it is notwithstanding very troublesome for the Sight, especially if it be bright: Therefore the Quadrant is much better, as will be shewed in the next Chapter.

Thus I have shewed you how to take an Observation by the Fore-Staff. The next thing that followeth in course, will be to shew you how to work your Observation; for which take these following Rules.

Observation. If the Sun hath North Declination, and be on the Meridian to the Southward of you, then you must subtract the Sun's Declination from your Meridian Altitude, and that Remainder is the height of the Equinoctial, or the Complement of the Latitude North. But if you be in South Latitude, add the Sun's Declination to the Meridian Altitude, and from the Sum abate 90 deg. the remainder is the Latitude. But if the Sun hath South Declination, you must add the Sun's Declination to your Meridian Altitude, and the Sum is the height of the Æquator, or the Complement of the Latitude North. If the Sun hath North Declination, and be on the Meridian to the Northward, then add the Sun's Declination to his Meridian Altitude, and the Sum is the height of the Æquator, or the Complement of the Latitude South, if the said Sum doth not exceed 90 deg. but if it doth exceed 90 deg. you must subtract 90 deg. from the said Sum, and the remainder is your Latitude North. If the Sun hath South Declination, and be to the Northward at Noon, you must then Subtract the Sun's Declination from his Meridian Altitude, and the remainder is the Complement of your Latitude South. When the Sun hath no Declination, then the Meridian Altitude is the Complement of the Latitude. If the Sun be in the Zenith, and if at the same time the Sun hath no Declination, then you are under the Equinoctial. But if the Sun hath North Declination, and in the Zenith, then look how many deg. and min. the Declination is, and that is the Latitude North. But if your Declination be South, then are you in South Latitude. If you observe the Sun or Star upon the Meridian beneath the Pole, then add your Meridian Altitude to the Complement of the Sun or Stars Declination, and the Sum is the height of the Pole.

Example in the North Latitude.

I observe at Sea the Sun's Meridian Altitude to be 39 deg. 32 min. and the same time the Sun's Declination is 15 deg. 20 min. N. I demand the Latitude I am in.

	deg.	min.	
The Meridian Altitude	39	32	
The Declination North, subtr.	15	20	
The Complement of the Latitude	24	12	
	90	00	
The Latitude I am in	65	48	North.

Suppose I were in a Ship at Sea the 18th of *April*, and by Observation I find the Sun's Meridian Altitude to be 62 deg. 15 min. The Latitude is required.

The Meridian Latitude	62	15
The Declination North, subtr.	14	18
The Complement of the Latitude	47	57
	90	00
The Latitude I am in	42	03

Admit you were in a Ship at Sea the 5th of *November* 1696. and I find the Sun's Meridian Altitude to be 24 deg. 56. min. The Latitude is required.

The Meridian Altitude	24	56
The Declination South, add	18	37
The Complement of the Latitude	43	33
	90	00
The Latittude I am in	46	27

Suppose a Ship at Sea the 27th of *May*, 1696. and I find the Sun's *Meridian Altitude* by Observation 56 deg. 45 min. The Latitude is required.

The *Meridian Altitude*	56	45
The Declination North, subtr.	22	46
The Complement of the Latitude	33	59
	90	00
The Latitude required I am in	56	01

Admit a Ship at Sea the 11th of *June* 1698. and find the Sun's *Meridian Altitude* by Observation 79 deg. 30 min. North. It is required to find the Latitude I am in.

The *Meridian Altitude*	79	30
The Delination North, add	23	31
	103	01
	90	00
The Latititude I am in	13	01

Suppose I were at Sea the 14th of *May*, 1696. and the *Meridian Altitude* of the Sun was 69 deg. 3 min. North, I demand the Latitude the Ship is in at that time.

The *Meridian Altitude*	69	03	
The Declination North	20	57	add
	90	00	
	90	00	
The Ship is under	00	00	the Equino.

Examples

Examples in South Latitude.

Admit I were at Sea the 2d of *June*, 1696. and I find the Sun's *Meridian Altitude* by Obſervation to be 64 deg. 45 min. What Latitude is the Ship in?

	deg.	min.	
The *Meridian Altitude North*	64	45	
The Declination North, add	23	15	
The Complement of the Latitude	88	00	
	90	00	
The Latitude the Ship is in	02	00	South.

Suppoſe a Ship at Sea the 28th of *December*, 1695. and in Longitude 169 deg. Eaſt, and I find the *Meridian Altitude* by Obſervation to be 59 deg. 52 min. The Latitude the Ship is in, is required. The Dclination in the *Meridian* of *London* for the 28th of *December*, is 22 deg. 25 min. and the daily difference of Declination is at this time 8 min. Therefore if you look in the Table of Proportion following, you will find the Proportional minutes to be about 4, which you muſt add to the Declination of the *Meridian* of *London*, and the Sum will be the Declination for the Longitude 169 deg. Eaſt, which is 22 deg. 29 min.

The *Meridian Altitude* North	59	52	
The Declination South, ſubtr.	22	29	
The Complement of the Latitude	37	23	
	90	00	
The Latitude the Ship is in	52	37	South.

Suppoſe I were at Sea in a Ship the 29th of *June*, 1679. And I find the Sun's *Meridian Alitude* to be 62 deg. 23 min. North. The Latitude is required.

The *Meridian Altitude North*	62	23	
The Declination North, add	22	26	
The Complement of the Latitude	84	49	
	90	00	
The Latitude the Ship is in	05	11	South.

Admit a Ship where at Sea, the Sun's Declination 13 deg. 53 min. South, and the Sun's Meridian Altitude 80 deg. 43 min. South, The Latitude is required.

The Declination South	13	53	
The *Meridian* Altitude	80	43	*add.*
	94	36	*the Sum.*
Subtr.	90	00	
The Latitude the Ship is in	04	36	*South.*

If you obſerve the upper part of the Sun, you muſt ſubtract 16 min. if you obſerve the lower part of the Sun, you muſt add 16 min. for the Sun's Semidiameter, and the Sum will be the true Altitude of the Sun's Center.

Examples of the Stars in North Latitude.

Suppoſe I am at Sea, and obſerve the Brighteſt of the 7 Stars upon the *Meridian*, and find his *Meridian Altitude* to be 47 deg. 20 min. and the Latitude were required.

The

	deg.	min.	
The Declination of this Star is	23	03	*North.*
The *Meridian* Altitude	47	20	
Subtract the North Declination	23	03	
The Complement of the Latitude	24	17	
	90	00	
The Latitude I am in	65	43	*North.*

Admit I were at Sea, and observe *Hydra's* Heart on the *Meridian*, his Altitude is 36 deg. 15 min. and his Declination is 7 deg. 15 min. South, The Latitude of the Place is demanded.

The *Meridian* Altitude is	36	15	
The Declination is South	07	15	*add.*
The Height of the Equinoctial above	43	30	*the Horizon.*
	90	00	
The Latitude the Ship is in	46	30	*required.*

This is plain, and needs no further Precept, but what is already concerning the Sun.

CHAP. XIV. *A Description and Use of the Sea Quadrant.*

THE Quadrant is formed of two Arches; from e to d, the lesser Arch contains 60 Degrees, and is called the Sixty Arch; the greater from g to F, contains 30 Degrees, and is called the Thirty Arch. To the Quadrant also belong three Sights or Vanes; the Horizon-Vane at A, the Shadow-Vane at B, and the Sight-Vane at C.

Set the Vane B to 15 or 20 deg. less than the Complement of the Altitude of the Sun required; then look through the Vane C, to the upper Edge of the Slit in the Horizon-Vane, and cause the upper edge of the Shadow of the Shadow-Vane to fall upon the upper Edge of the Slit in the Horizon-Vane, and then if you see all Skie and no Water, then put your Sight-Vane a little higher towards g; but if you see all Water and no Skie, then pull your Eye-Vane lower towards F; and when you have done so, observe again; and then if you see the Shade lie upon the upper part of the Slit, on the Horizon-Vane, and you at the same time do see the Horizon through the Horizon-Vane, then that is all you can do until the Sun be risen higher; and so tend the Sun until he be upon the Meridian; and when he is descending, or as we commonly say, fallen, you will see nothing but the Skie; and your Vanes being fast in this posture, you have done observing the Sun upon the *Meridian* that Day: Therefore reckon the Degrees from e to B to the middle of the Shadow-Vane; to which add the number of Degrees from F to the Eye-Sight, and their Sum is the distance of the Sun from the Zenith.

Rule

Rules to find the Latitude by observing with the Quadrant.

First, If the Sun hath North Declination, and you be in North Latitude, and the Sun upon the *Meridian*, South of you; then if you add the Sun's Declination to his Zenith-Distance, (that is, the Complement of the Sun's Meridian Altitude) the Sum will be the Latitude you are in. But if the Sun hath South Declination, and you be in North Latitude, you must subtract the Declination from the Complement of the *Meridian* Altitude, and the Remainder will be the Latitude the Ship is in. If you be to the Southward of the Æquinoctial, and the Sun's Declination Southerly, and come to the *Meridian* in the North; in such case you must add the Declination to the Zenith-distance, and the Sum will be your Latitude. But if the Sun be to the Northwards of the Æquinoctial, (that is, have North-Declination) and come to the *Meridian* in the North, you must subtract the Declination from the Zenith-distance, and the Remainder will be the Latitude.

If you be in North Latitude, and the Sun's Declination North; and the Sun come to the *Meridian* in the North; or if you be in South Latitude, and the Sun having South Declination come to the *Meridian* in the South: In both these Cases subtract the Zenith-distance from the Declination, the Remainder is the Latitude of the Place.

If you observe the Sun's *Meridian* Altitude under the Pole, add the Sun's Declination to the Zenith-distance, and subtract the Sum from 180 deg. the Remainder is the Latitude of the place.

Examples in North Latitude.

Admit being at Sea the 5th of *May*, 1694. by Observation I find the Sun to be distant from the Zenith 37 deg. 52 min. being upon the Meridian, what Latitude is the Ship in.

	deg.	*min.*
The distance of the Sun from the Zenith	37	52
North Declination	19	02
The Latitude required the Ship is in.	56	54

Suppose a Ship at Sea the 29th of *July*, 1682. and I find the Complement of the Sun's *Meridian Altitude* by Observation to be 33 deg. 10 min. The Latitude the Ship is in required.

The Distance of the Sun from the Zenith	33	10
North Declination, *add*	16	07
The Latitude the Ship is in	49	17

Suppose a Ship at Sea the 13th of *September* 1683. and I find the Complement of the Sun's Meridian Altitude, or distance from the Zenith, 45 deg. 58 min. I demand what Latitude the Ship is in.

The Zenith-distance of the Sun	45	58
The Declination South, *subtract*	00	07
The Latitude the Ship is in	45	51

Admit a Ship were at Sea the 4th of *December*, *Anno* 1690. and the Complement of the Sun's Meridian Altitude that were 49 deg. The Latitude the Ship is in, is required.

The Sun is distant from the Zenith	49	23
The Sun's Declination South, *subtract*	23	20
The Latitude the Ship is in	26	03

Suppose I were in a Ship at Sea the 23d of *May*, 1695, and am also in Longitude to the East of the Meridian of *London* 135 deg. and I find the Complement of the Meridian Altitude by Observation to be 13 deg. 28 min. The Latitude is required.

	deg.	min.
Declination in the *Meridian* of *London*	22	17
The Proportional Minutes, *subtract.*	00	03
The Sun's Declination in the Meridian given	22	14
The Zenith-distance of the Sun *subtr.*	13	28
The Latitude the Ship is in	08	46

Examples in South Latitude.

Admit a Ship at Sea the 7th of *July*, 1695, and the Sun being upon the *Meridian*, I find the Complement of his *Meridian* Altitude by Observation to be 42 deg. 50 min North. The Latitude is demanded.

The Sun's distance from the Zenith	42	50
The Declination North, subtract	21	16
The Latitude the Ship is in	21	34

Admit I were in a Ship the 5th of *November*, 1687. and the difference of Longitude from *London* 120 deg. West, and the Complement of the Sun's *Meridian* Altitude by Observation is 31 deg. 53 min. North, the Latitude is required the Ship is in.

The Sun's distance from the Zenith	31	53	
The Declination South, at *London*	18	37	
The Proportional Minutes	00	05	*Added.*
The Sun's Declination in the Meridian given	18	42	
Which add to the Zenith-distance	31	53	
The Latitude the Ship is in	50	35	

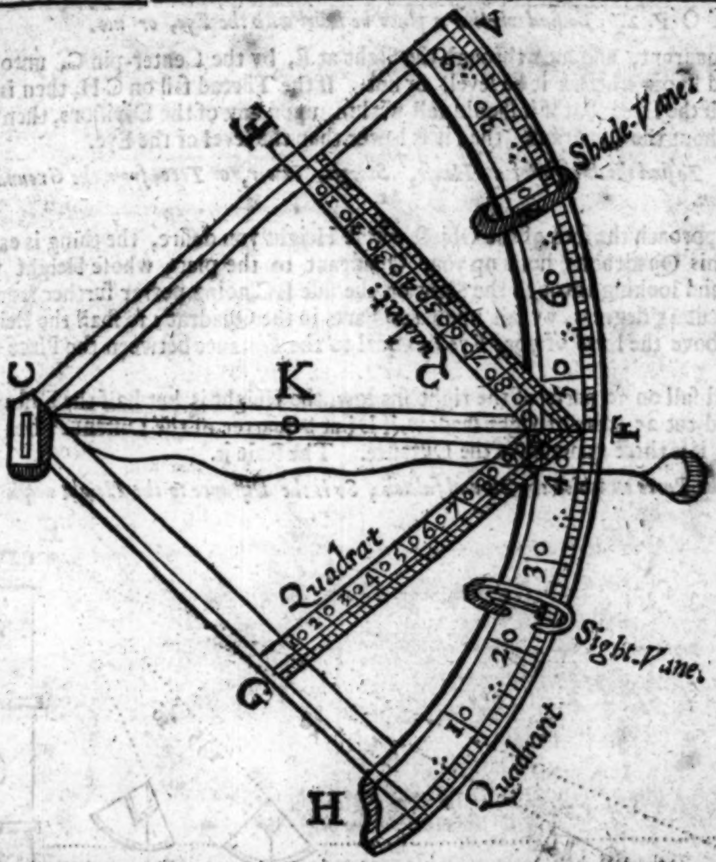
Suppose I were in a Ship at Sea to the Southward of the Æquinoctial, the 3d of *January*, 1683. and I find the Sun upon the South part of the Meridian, and the Complement of the Meridian Altitude is 14 deg. 38 min. The Lat. the Ship is in is required.

The Sun's distance from the Zenith	14	38
The Declination South	21	28
The Latitude the Ship is in	06	50
	06	50

CHAP. XV. *The Description and Use of a Quadrant for the taking Altitudes on Land or Sea, of the Sun or Stars, or the Altitude of Hills, Trees, Steeples, Castles, or any other Object.*

THis Quadrant is to be made of well-seasoned and smooth dry Box or Pear-tree. The Semidiameter of the Quadrant is about 19 or 20 Inches. The Arch of the Quadrant is divided into 90 Degrees first, and each degree into 6 equal parts, each part being 10 Minutes, which is near enough for Sea or Land-Observations, and numbred as you see from 10 to 90 deg. In this Quadrant is inscribed the Quadrat C E F G, whose sides G F, and F E are divided into 100 equal parts. On the side G F are the parts of Right Shadow; on the other side E F are the parts of contrary Shadow. In the Center at C there is a Brass-pin, on it to hang a Thread and Plummet; and on one of the sides there is a Sight made of Brass at E. There is also an Horizon-Vane, let in upon the Center C, and a Shade-Vane and Sight-Vane, for Back-Observation. The Use of this Quadrant is as follows.

Example.



Examp. Admit I am ashore, and would know the Sun's Meridian Altitude, and true Latitude of the Place. Take the Altitude thus; The String and Plummet being hanged on the Center C, turn the Brass-Pin to the Sun, and hold up the Center until the shade of the Brass-Pin strikes on the Sight and line at E, the Thread and Plummet playing easily by the side; mark where it cuts the Arch of the Quadrant, as at F, that is the Sun's Altitude, and reckoned from H; and the Latitude is found by the same Rules as you have been given in the Use of the Fore-staff. The best way to hold the Quadrant steady, is to skrew it with a Brass-Pin at K, to a staff set perpendicular, and then you may raise it by degrees, as the Sun rises.

PROP. 1. *For Back-Observation at Sea.*

Take the Handle of the Quadrant at H in your hand, after the Vanes are set on, and fix the Shade-Vane; then hold your Quadrant upright; then bring your Sight Vane to your Eye, and look through your Sight upon the Horizon-Vane. You must be sure to hold your Quadrant so, that the upper part of the shadow of your Shade-Vane may fall upon the upper part of the slit of your Horizon-Vane, and look through the slit for the Horizon: but if you cannot see the Horizon, but all Skie and no Water, you must put your Sight-Vane a little higher towards V; but if, on the contrary, you do see all Water and no Skie, then slide your Sight-Vane a little lower towards H, and then make Observation again, and if the upper part of the shade do lie upon the upper part of the slit, and you see the Horizon at the same time, then you have the Sun's present Altitude, and you must wait longer as your judgment informs you, till the Sun is upon the *Meridian*, and observe as you did before: and if the Sun be to the Westward of the *Meridian*, and falling, you will see all Skie and no Water, and the work is done for that day. Then look what degrees the Shade-Vane is put at, which in the Figure is at 70 deg. which note. Look also what degrees and minutes do stand against your Sight-Vane, which subtract from the former degrees by the Shade-Vane, and the Remainder is the Sun's *Meridian* Altitude. As in the Figure, the Sight-vane is at 25 deg. 30 min. which taken out of 70 deg. the Remainder is 44 deg. 30 min. the Sun's Altitude. And the way of working your Observation, is the very same as you have been given in the Use of the Fore-staff.

PROP.

PROP. 2. *To find whether a place be level with the Eye, or not.*

Take the Quadrant, and look through the Sight at E, by the Center-pin C, unto the place you would know whether it be level, or not. If the Thread fall on C H, then is the Place level with the Eye; but if it should fall within, upon any of the Divisions, then it is higher; if without the Quadrant, then it is lower than the level of the Eye.

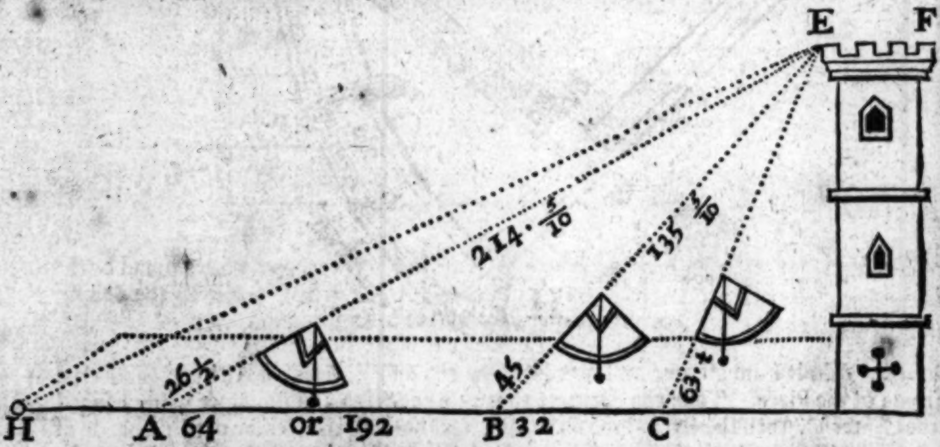
PROP. 3. *To find the Height of an House, Steeple, Tower, or Tree, from the Ground at one Observation.*

If you can approach the foot of the Object whose Height you desire, the thing is easily performed by this Quadrant; hold up your Quadrant to the place whose Height you would know, and looking through the Sight on the side E C, going nearer further from it till the Thread cut 45 degrees, or fall upon 100 Parts in the Quadrat: so shall the Height of the Object above the level of your Eye, be equal to the Distance between the Place and your Eye.

If the Thread fall on 50 parts of the right shadow, the Height is but half the Distance.

If the Thread cut 25 parts of right shadow, it is but a quarter of the Distance; but if it fall on 75 parts, it is three quarters of the Distance. The Rule is.

As 100, *to the Parts on which the Thread falleth; So is the Distance to the Height required.*



But when the Thread shall fall on the parts of the contrary shadow, then if it fall on 50 Parts, the Height is double unto the Distance. If on 25, it is four times the Distance. If the Thread fall upon the contrary shadow, this is the Rule.

As the Parts cut by the Tread, are unto 100: *So is the Distance unto the Height.*

PROP. 4. *The Distance being given to find the Altitude at two Stations.*

Suppose E D were a Tower or Steeple, whose Altitude you would know, and you cannot come so near as to measure between your Station of 45 deg. and the Base of the Object, by reason of some Wall or Moat; yet by the proportion of the Line of Quadrature, you may help your self by another Station. Thus if you could not measure the Distance from B to D. then go backward from B to A, until the Thread cut the 26 deg. 30 min. of your Quadrant; and measure the Distance between B and A: As suppose it to be 32 Foot or Yards, which is equal to the Height D E 32; the whole Line D A being 64 Feet or Yards, double to the Height. But if you cannot come so near the foot of the Object as to make an Angle of 45 deg. then take two other convenient Stations, and observe the two Angles at those Stations, measuring the Distance between the Stations. Then subtract the greater of the two Angles from 180 deg. and to the Remainder add the lesser Angle observed, and subtract that Sum from 180 deg. and note this Remainder. Then say,

As the Sine of the last remaining Angle, To the Distance between the two Stations:
So is the Sine of the lesser Angle observed, To a fourth Number. And

As this fourth Number to Radius:
So is the Sine of the greater Angle observed, to the height of the Object required.

Example. Suppose the Angle at the first Station to be 43 deg. 50 min. and the Angle at the Second Station to be 30 Degrees, 58 Minutes, and the distance betwixt the two

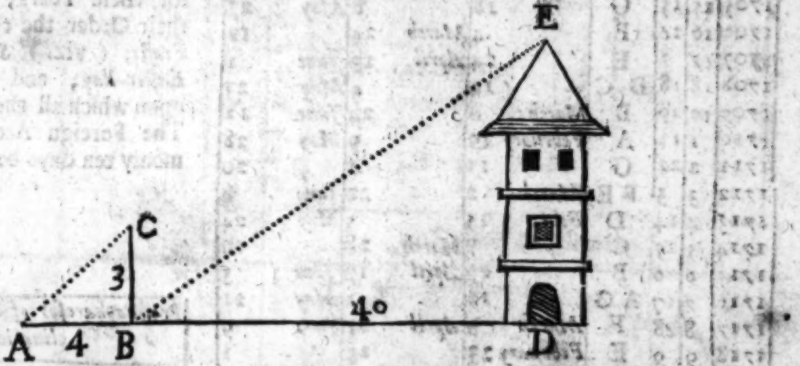
two ſtations 60 Yards: to find the Altitude of the Object above the Level of the Eye. The greater Angle ſubtracted from 180 deg. leaves 136 d. 10 m. to which adding the leſſer Angle, the Sum is 166 deg. 8 min. which ſubtracted from 180 deg. leaves 12 deg. 52 min. Then,

As Sine 12 deg. 52 min. To the diſtance of the two Stations, 60 Yards.
So is the Sine of the leſſer Angle, 30 d. 58 m. To a 4th Number, which is 130 Yards.

Then, As the fourth Number, 138 Yards. To Radius:
So is the Sine of the greater Angle, 43 d. 50 m. To the Alt. required, 95 Yards $\frac{1}{2}$.

PROP. 5. *By the height of the Sun, and the length of the Shadow, to find the height of any Tree, Tower, or Steeple.*

This Concluſion may be tried by a little Quadrant, by which you may take the Sun's Altitude to $\frac{1}{3}$ or $\frac{1}{4}$ of a deg. which is near enough for theſe Concluſions.



Suppoſe D E to be a Turret, or Steeple, whoſe height is required to be found by the ſhadow it makes on Level Ground, the Rule is thus, *viz.* Let the height of the Sun be 37 deg. 00 min. and the length of the Shadow 40 Foot, the Rule is,

As the Radius 90 deg.——————————10
To the length of the Shadow 40 Foot——————————160206
So is the Tangent of the Sun's height 37 deg.——————————987711
To the height of the Thing deſired——————————147917

which is found to be 30 $\frac{14}{100}$ parts, which ſhews the height to be a little above 30 Foot.

Here is another way to do the ſame without the help of a Quadrant, *viz.* Set up a Staff of any length, ſuppoſe 3 Feet, as C B, and the Shadow which it makes from B to A is 4 Feet; and becauſe the ſhadow of the Tower from the Baſe thereof to B is 40 Feet, I ſay;

As the Shadow of the Staff, is to the height of the Staff:
So is the Shadow of the Steeple, to the height of the Steeple.

The Operation may be performed by Natural Numbers, or by Logarithms, thus, *viz.*
As 4 Feet, to 3: ſo 40 Feet to 30 Feet.

$$\begin{array}{l} \;3 \\ \hline \cancel{1}20 \;\;(30 \\ \;44 \end{array}$$

As the Shadow of the Staff 4 Feet A B, Log.——————————0,60206
To the length of the Staff 3 Feet B C——————————0,47712
So is the Shadow of the Steeple 40 Feet D B——————————1,60206
2,47918
To the height of the Tower 30 Feet D E——————————1,47712

T

A

A TABLE of the Prime, Epact, Dominical Letters, *and* Leap-Years; Shrove-Sunday, Easter-Sunday, Whit-Sunday, *for Twenty six Years.*

Years	Prime.	Epact.	Dom. Let.	Shrove-Sunday.		Easter-Sunday.		Whit-Sunday.	
1699	9	9	A	*February*	19	*April*	9	*May*	28
1700	10	20	G F		11	*March*	31		19
1701	11	1	E	*March*	2	*April*	20	*June*	8
1702	12	12	D	*February*	15		5	*May*	24
1703	13	23	C		7	*March*	28		16
1704	14	4	B A		27	*April*	16	*June*	4
1705	15	15	G		18		8	*May*	27
1706	16	26	F		4	*March*	24		12
1707	17	7	E		24	*April*	13	*June*	1
1708	18	18	D C		14		4	*May*	23
1709	19	29	B	*March*	6		24	*June*	12
1710	1	11	A	*February*	19		9	*May*	28
1711	2	22	G		11		1		20
1712	3	3	F E	*March*	2		20	*June*	8
1713	4	14	D	*Febr.*	15		5	*May*	24
1714	5	25	C		7	*March*	28		16
1715	6	6	B		27	*April*	17	*June*	5
1716	7	17	A G		12		2	*May*	21
1717	8	28	F	*March*	3	*April*	21	*June*	9
1718	9	9	E	*February*	23		13		1
1719	10	20	D		8	*March*	29	*May*	17
1720	11	1	C B		28	*April*	17	*June*	5
1721	12	12	A		19		9	*May*	28
1722	13	23	G		4	*March*	25		13
1723	14	4	F		24	*April*	14	*June*	2
1724	15	15	E D		16		5	*May*	24

THis Table sheweth first, the Date of the Years; secondly, the *Prime*, or *Golden-Number*; thirdly, the *Epact*; fourthly, the *Dominical Letters* for these Years; and then in their Order the chief *Moveable-Feasts*, (viz.) *Shrove-Sunday*, *Easter-day*, and *Whit-Sunday*, upon which all the rest depend. The Foreign Account is commonly ten days before us.

Prosthapharesses of the Sun's Declination.

Day Month.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Octob.	Nov.	Dec.
	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.
1	17	36	42	40	28	8	15	33	42	[illegible]	30	9
2	18	37	43	39	28	7	15	34	43	42	29	8
3	19	37	43	40	27	6	16	35	43	42	29	7
4	20	38	44	40	27	5	17	35	43	42	28	6
5	20	37	44	39	26	4	18	34	43	41	28	5
6	21	37	43	39	25	4	19	35	43	41	28	4
7	21	38	43	38	25	3	19	35	44	31	27	3
8	22	39	43	38	24	2	19	35	43	40	26	2
9	24	38	44	38	23	2	20	36	44	40	25	1
10	24	39	45	37	23	1	21	36	43	40	24	1
11	25	39	44	37	22	0	21	37	43	40	24	0
12	25	40	44	37	22	1	22	38	43	39	23	0
13	26	41	43	37	21	1	22	38	43	39	22	1
14	26	40	44	37	20	2	23	38	44	38	21	2
15	27	41	44	35	20	3	23	38	43	38	21	3
16	28	42	43	35	19	4	24	39	44	37	20	4
17	28	41	42	35	19	4	25	39	43	38	20	5
18	29	41	43	35	18	5	26	39	43	37	19	6
19	30	41	43	34	17	6	26	39	43	37	18	7
20	31	42	42	34	17	7	27	40	43	36	17	8
21	31	42	43	33	16	8	27	40	43	36	16	9
22	32	42	43	33	15	8	28	41	44	35	16	10
23	32	43	43	32	14	9	29	40	43	35	15	11
24	32	43	42	32	14	10	29	41	42	34	14	11
25	33	44	42	31	12	11	30	41	43	34	13	12
26	33	44	41	31	12	12	30	41	42	33	13	13
27	34	43	41	30	11	13	30	41	42	34	12	14
28	35	43	41	29	9	14	31	41	43	32	11	16
29	35	43	41	29	9	14	31	31	43	32	11	16
30	35		41	29	9	14	32	42	42	32	10	16
31	36		41		8		33			31		17

How to Rectifie the Tables of the Sun's Declination at any time by Prosthapheresses.

The Use of the Table.

THe Sun's Declination in this Kalender is Calculated for the Years 1665, 66, 67, and 68. but for any Year after 1668, the Rule is thus. *Example.* I would know the Sun's Declination for the Year 1689. you must always subtract 1668 from the Year given, which is here 1689, the remainder is 21 Years; which being divided by 4, the Quotient is 5 Leap-Years, and 1 remains, which sheweth it is the first Year after Leap-Year. Now I desire to rectifie the Table for the first day of *April*, which in the Kalender you have 8 deg. 39 min. and in this Table you have 40 sec. which multiplied by 5 Leap-Years, give 200 sec. that is 3 min. 20 sec. to be added to 8 deg. 39 min. So you have 8 deg. 42 min. for the Sun's Declination in 1689.

When the Declination increaseth then add; and for decreasing subtract.

JANUARY XXXI Days.

Leap ye.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

South Declination.

Day Mo.	Da Week	☽ Epact.	Hour.	☉ Rising and Sett.	Leap ye. Deg.	Min.	Differ.	First. Deg.	Min.	Differ.	Second. Deg.	Min.	Differ.	Third. Deg.	Min.	Differ.
1	A	29		Circumcis.	21	50		21	43		21	45		21	47	
2	B	28		4 1 8	21	40	10	21	33	10	21	35	10	21	38	9
3	[illegible]	26	12	4 2 8	21	30	10	21	22	11	21	25	10	21	28	10
4	D	25	08	4 3 8	21	20	10	21	11	11	21	14	11	21	17	11
5	E	23	21	4 4 8	21	09	11	21	00	11	21	03	11	21	6	11
6	F	*		Twelf-day	20	57	12	20	48	12	20	51	12	20	54	12
7	G	22	10	4 7 8	20	45	12	20	36	12	20	39	12	20	42	12
8	A	21		4 8 8	20	33	12	20	24	12	20	27	12	20	30	12
9	B	20	06	☉ in ♒.	20	21	12	20	11	13	20	14	13	20	17	13
10	C	18	18	4 11 8	20	8	12	19	58	13	20	01	13	20	4	13
11	D	*		4 12 8	19	55	13	19	44	14	19	49	14	19	51	13
12	E	17	15	4 14 8	19	41	14	19	30	14	19	33	14	19	37	14
13	F	16		*Hilary.*	19	27	14	19	16	14	19	19	14	19	23	14
14	G	15	03	4 11 8	19	12	15	19	01	15	19	04	15	19	8	25
15	A	*		4 18 8	18	57	15	18	46	15	19	50	14	18	54	14
16	B	14	0	4 20 8	18	43	15	18	31	15	18	35	15	28	39	15
17	C	12	12	4 21 8	18	27	15	18	15	16	18	19	16	18	23	16
18	D	*		4 23 8	18	11	16	17	59	16	18	03	16	18	7	16
19	E	11	1	☉ 10 ♒.	17	55	16	17	42	17	17	47	16	17	51	16
20	F	9	0		17	38	17	17	26	16	17	30	17	17	34	17
21	G	7	10		17	22	16	17	9	17	17	13	17	17	17	17
22	A	*			17	5	17	16	51	18	16	56	17	17	00	17
23	B	6	6	Term beg.	16	47	18	16	34	17	16	38	18	16	42	18
24	C	4	18	4 33 8	16	30	17	16	16	18	16	20	18	16	25	17
25	D	*		Conv. Paul.	16	12	18	15	58	18	16	02	18	16	7	18
26	E	3	7	4 37 8	15	54	18	15	40	18	15	44	18	15	49	18
27	F	2	0		15	35	19	15	21	19	15	25	19	15	30	19
28	G	1	3		15	16	19	15	2	19	15	07	18	15	11	19
29	A	*			14	57	19	14	43	19	15	48	19	14	52	19
30	K	29	16		14	38	19	14	22	21	14	28	20	14	33	19
31	C	28	12	4 46 8	14	18	20	14	4	28	14	08	20	14	13	20

South Declination.

FEBRUARY XXVIII Days.

Leap ye.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Da. Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising. and Sett.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	D	27		4 18 8	13	59		13	44		13	48		13	53	
2	E	26	1	Purif. Mar.	13	39	20	13	24	20	13	28	20	13	33	20
3	F	25			13	10	20	13	3	21	13	8	20	13	13	20
4	G	23	10		12	58	22	12	43	20	12	48	20	12	52	21
5	A	22	22		12	38	20	12	22	21	12	27	21	12	32	20
6	B	21			12	17	21	12	1	21	12	6	21	12	11	21
7	C	20	18	4 59 8	11	56	21	11	40	21	11	45	21	11	50	21
8	D	19		☉ in ♓.	11	35	21	11	19	21	11	24	21	11	29	21
9	E	18	8		11	14	21	10	57	22	11	2	22	11	8	21
10	F	18	18		10	52	22	10	36	21	10	40	22	10	47	21
11	G	17	3		10	30	22	10	14	22	10	19	21	10	24	23
12	A	15	16	Term ends	10	8	22	9	52	22	9	57	22	10	2	22
13	B	*		5 11 7	9	46	22	9	30	22	9	35	22	9	40	22
14	C	14	12	Valentine.	9	24	22	9	7	23	9	13	22	9	18	22
15	D	13		5 14 7	9	2	22	8	45	22	8	50	23	8	55	23
16	E	12	1	5 16 7	8	39	22	8	22	23	8	27	23	8	33	22
17	F	11	14	5 18 7	8	17	23	8	0	22	8	5	22	8	11	22
18	G	9	10	☉ 10 ♓.	7	54	23	7	37	23	7	42	23	7	44	22
19	A	8		5 22 7	7	31	23	7	14	23	7	20	22	7	26	20
20	B	7	0	5 24 7	7	8	23	6	51	23	6	57	23	7	3	25
21	C	6	19	5 26 7	6	45	23	6	28	24	6	34	23	6	39	24
22	D	5		5 28 7	6	22	23	6	4	23	6	10	24	6	16	23
23	E	4	7	5 30 7	5	59	23	5	41	23	5	47	23	5	53	23
24	F	3	20	Matthew.	5	36	23	5	18	23	5	24	23	5	30	23
25	G	2		5 34 7	5	12	24	4	55	24	5	0	24	5	5	25
26	A	1	16	5 36 7	4	49	23	4	31	23	4	37	23	4	43	22
27	B	*		5 38 7	4	25	24	4	8	24	4	13	24	4	19	24
28	C	29	5	☉ 20 ♓.	4	2	23	3	44		3	50	23	3	56	23
					3	39	23									

South Declination.

MARCH XXXI Days.

Leap yr.	*First.*	*Second.*	*Third.*
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Day Mo.	*Da. Week*	☽ *Epact.*	*Hour.*	☉ *Rising and Sett.*			*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	
1	D	28	1	David.			3	15		3	20		3	26		3	32		
2	E	26	14	5	44	7	2	51	24	2	57	23	3	3	23	3	9	23	*South Declination.*
3	F	*		5	46	7	2	28	23	2	33	24	2	29	24	2	45	24	
4	G	25	10	5	48	7	2	4	24	2	9	24	2	16	13	2	21	24	
5	A	24		5	50	7	1	40	24	1	46	23	1	52	24	1	58	23	
6	B	23	0	5	52	7	1	16	24	1	22	24	1	28	24	1	34	24	
7	C	21	11	5	54	7	0	53	23	0	59	23	1	5	23	1	11	23	
8	D	21		5	56	7	0	29	24	0	35	24	0	41	24	0	46	24	
9	E	20	7	5	58	7	0	5	24	0	11	24	0	17	24	0	23	23	
10	F	18	20	☉	in	♈.	*Nor.*	18	24	*Nor.*	13	24	*North*	6	11	*North*	1	22	*Æquinoctial*
11	G	*		6	2	6	0	42	24	0	37	23	0	30	24	0	25	24	
12	A	17	16	6	4	6	1	6	23	0	00	24	0	54	24	0	49	24	
13	B	16		6	6	6	1	29	24	1	24	23	1	18	24	1	12	23	
14	C	15	5	6	8	6	1	53	23	1	47	24	1	42	24	1	36	24	
15	D	14	1	6	10	6	2	16	24	2	11	24	2	5	23	2	00	23	
16	E	12	14	6	12	6	2	40	24	2	35	23	2	29	24	2	23	23	*North Declination.*
17	F	*		6	14	6	3	4	23	2	58	23	2	52	23	2	46	23	
18	G	11	2	6	16	6	3	27	23	3	21	24	3	15	23	3	10	24	
19	A	10		6	18	6	3	50	24	3	45	23	3	39	24	3	33	23	
20	B	9	0	☉	10	♈.	4	14	23	4	8	23	4	2	23	3	56	23	
21	C	7	11	6	22	6	4	37	23	4	31	23	4	25	23	4	19	23	
22	D	*		6	24	6	5	00	21	4	54	23	4	49	24	4	43	24	
23	E	6	7	6	26	6	5	23	23	5	17	23	5	12	23	5	6	23	
24	F	4	20	6	28	6	5	46	23	5	40	23	5	35	23	5	29	23	
25	G	*		An. Mary			6	9	23	6	3	23	5	57	22	5	52	23	
26	A	3	8	6	32	6	6	31	22	6	25	22	6	20	23	6	15	23	
27	B	2		6	34	6	6	45	23	6	48	23	6	42	22	6	37	22	
28	C	1	7	6	36	6	7	16	22	7	11	22	7	5	23	7	0	23	
29	D	29	17	6	38	6	7	38	22	7	33	22	7	28	23	7	22	22	
30	E	28	14	☉	20	♈.	8	1	23	7	55	22	7	50	22	7	45	23	
31	F	27		6	42	6	8	23	22	8	17	22	8	12	22	8	7	22	

APRIL XXX Days.

Leap ye.	*First.*	*Second.*	*Third.*
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Da. Mo.	*Da. Week*	☽ *Epact.*	*Hour.*	☉ *Rising. and Sett.*			*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	G	26	2	6	44	6	8	45		8	39		8	34		8	29	
2	A	25	22	6	46	6	9	7	22	9	01	22	8	56	22	8	51	22
3	B	24	0	6	48	6	9	29	22	9	23	22	9	18	22	9	13	22
4	C	23	11	6	50	6	9	50	21	9	44	21	9	39	21	9	34	21
5	D	*		6	52	6	10	11	21	10	06	22	10	01	22	9	56	22
6	E	22	0	6	54	6	10	32	21	10	27	21	10	22	21	10	17	21
7	F	20	20	6	56	6	10	53	21	10	48	21	10	43	21	10	38	21
8	G	19		6	57	6	11	14	21	11	09	21	11	04	21	10	59	21
9	A	18	9	6	59	6	11	35	21	11	30	20	11	25	21	11	20	21
10	B	*		☉	in	♉.	11	55	20	11	50	20	11	46	21	11	40	20
11	C	17	5	7	2	5	12	15	20	12	10	20	12	06	20	12	01	21
12	D	15	6	7	4	5	12	35	20	12	30	20	12	26	20	12	21	20
13	E	14	14	7	6	5	12	55	20	12	50	20	12	46	20	12	41	20
14	F	13		7	8	5	13	15	20	13	10	19	13	06	20	13	01	20
15	G	12	2	7	10	5	13	34	19	13	29	19	13	25	19	13	20	19
16	A	11	15	7	11	5	13	53	19	13	48	19	13	44	19	13	40	20
17	B	10		7	13	5	14	12	19	14	07	19	14	03	19	13	59	19
18	C	9	11	7	15	5	14	31	19	14	26	19	14	22	19	14	18	19
19	D	8		7	17	5	14	50	19	14	45	18	14	41	19	14	36	18
20	E	7	0	☉	10	♉.	15	08	18	15	03	18	14	59	18	14	55	19
21	F	6	20	7	29	5	15	26	18	15	21	18	15	17	18	15	13	18
22	G	5		7	22	5	15	44	17	15	39	17	15	35	18	15	31	18
23	A	4	9	George.			16	01	17	15	56	18	15	53	18	15	48	17
24	B	3	21	7	25	5	16	18	17	16	14	17	16	10	17	16	06	18
25	C	2		Mark.			16	35	17	16	31	16	16	27	17	16	23	17
26	D	1	18	7	49	5	16	52	17	16	47	18	16	44	17	16	40	17
27	E	*		7	31	5	17	59	16	17	05	16	17	01	17	16	57	17
28	F	29	6	7	32	5	17	25	16	17	21	16	17	17	16	17	13	16
29	G	28	2	7	34	5	17	41	15	17	37	16	17	33	16	17	29	16
30	A	27		☉	20	♉.	17	56	15	17	52	15	17	49	16	17	44	15

North Declination.

North Declination.

MAY XXXI Days.

Leap ye.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

North Declination.

Day Mo.	Da. Week	☽ Epact.	Hour.	⊙ Rising and Sett.			Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	B	*		Phil. & Jac.			18	11		18	8		18	4		18	00	
2	C	25	11	7	39	5	18	26	15	18	23	15	18	19	15	18	15	15
3	D	24		7	40	5	18	41	15	18	37	14	18	34	15	18	30	15
4	E	23		7	42	5	18	55	14	18	52	15	18	48	14	18	45	15
5	F	22	13	7	44	5	19	9	14	19	6	14	19	2	14	18	59	14
6	G	21		7	45	5	19	25	14	19	19	13	19	21	14	19	13	14
7	A	20	9	7	46	5	19	36	14	19	33	14	19	30	14	19	27	14
8	B	18	21	7	47	5	19	49	13	19	46	13	19	43	13	19	40	13
9	C	*		7	49	5	20	2	13	19	52	13	19	56	12	19	53	13
10	D	17	18	⊙	in	II.	20	14	12	20	11	12	20	8	12	20	5	12
11	E	16		7	50	5	20	26	12	20	24	13	20	20	12	20	18	13
12	F	15	6	7	53	5	20	38	12	20	36	12	20	32	12	20	30	12
13	G	14	2	7	54	5	20	49	11	20	47	11	20	43	12	20	41	11
14	A	12	15	7	55	5	21	00	11	20	57	12	20	55	11	20	52	11
15	B	*		7	56	5	21	11	10	21	9	10	21	6	10	21	3	11
16	C	11	4	7	57	5	21	21	10	21	19	10	21	16	10	21	14	11
17	D	10		7	58	5	21	31	9	21	29	9	21	26	10	21	24	10
18	E	9	0	7	59	5	21	40	10	21	38	9	21	36	9	21	34	10
19	F	7	13	8	0	4	21	50	9	21	47	9	21	45	9	21	43	9
20	G	*		8	1	4	21	59	8	21	56	9	21	54	8	21	52	9
21	A	6	9	⊙	10	II.	22	7	8	22	5	8	22	2	9	22	1	9
22	B	4	1	8	3	4	22	15	7	22	13	8	22	11	9	22	9	8
23	C	*		8	4	4	22	22	7	22	21	7	22	19	7	22	17	8
24	D	3	10	8	5	4	22	29	7	22	28	7	22	24	7	22	31	7
25	E	2		8	6	4	22	36	7	22	35	6	22	33	7	22	38	7
26	F	1	6	8	7	4	22	43	6	22	41	6	22	40	6	22	45	7
27	G	29	19	8	8	4	22	49	6	22	47	6	22	46	6	22	51	6
28	A	28	15	8	8	4	22	55	5	22	53	5	22	52	5	22	56	5
29	B	27		8	9	4	23	00	5	22	58	5	22	57	5	23	1	5
30	C	26	4	8	10	4	23	5	4	23	3	5	23	2	5	23	6	5
31	D	*		8	10	4	23	9	4	23	8	5	23	7	5			

North Declination.

JUNE XXX Days.

Leap ye.	*Firſt.*	*Second.*	*Third.*
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Da. Mo.	*Da. Week*	☽ *Epact.*	*Hour.*	☉ *Riſing. and Sett.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	E	25	0	☉ 20 ♊.	23	13		23	12		23	11		23	10	
2	F	23	13	8 11 4	23	17	4	23	16	4	23	15	4	23	14	4
3	G	*		8 11 4	23	20	3	23	19	3	23	19	4	23	18	4
4	A	22	1	8 12 4	23	23	2	23	22	3	23	22	3	23	21	3
5	B	20	21	8 12 4	23	25	2	23	25	3	23	24	2	23	24	3
6	C	19		8 12 4	23	27	2	23	27	2	23	26	2	23	26	2
7	D	18	10	8 13 4	23	29	1	23	28	1	23	28	2	23	28	2
8	E	*		8 13 4	23	30	1	23	29	1	23	29	1	23	29	1
9	F	17	6	*Days at a*	23	31	0	23	30	1	23	30	1	23	30	1
10	G	15	19	*ſtand.*	23	31	0	23	31	1	23	31	1	23	31	1
11	A	14	15	☉ in ♋.	23	31	1	23	31	0	23	31	0	23	31	0
12	B	13		*Days*	23	30	1	23	31	0	23	31	0	23	31	0
13	C	12	4	*ſhorten.*	23	29	0	23	30	0	23	30	1	23	30	1
14	D	11	16	8 13 4	23	29	2	23	29	1	23	29	1	23	29	1
15	E	10		8 13 4	23	27	2	23	27	2	23	28	1	23	28	1
16	F	9	13	8 12 4	23	25	3	23	25	2	23	26	2	23	26	2
17	G	8		8 12 4	23	22	3	23	23	2	23	23	3	23	24	2
18	A	7	1	8 12 4	23	19	3	23	20	3	23	20	3	23	21	3
19	B	6	21	8 11 4	23	16	4	23	17	4	23	17	3	23	19	2
20	C	5		8 11 4	23	12	4	23	13	4	23	13	4	23	15	4
21	D	4	10	8 11 4	23	8	5	23	9	5	23	9	4	23	11	4
22	E	*		☉ 10 ♋.	23	3	5	23	4	4	23	5	4	23	6	5
23	F	3	0	8 10 4	22	58	5	23	0	5	23	1	4	23	2	4
24	G	1	19	John Bapt.	22	53	6	22	55	6	22	56	5	22	57	5
25	A	*		8 8 4	22	47	6	22	49	4	22	51	5	22	51	6
26	B	29	6	8 8 4	22	41	7	22	43	7	22	45	6	22	45	6
27	C	28	4	8 7 4	22	34	7	22	36	7	22	38	7	22	39	6
28	D	26	17	8 6 4	22	27	7	22	24	7	22	31	7	22	33	6
29	E	*		Peter Ap.	22	20	7	22	22	8	22	34	7	22	26	7
30	F	25	13	8 4 4	22	12	8	22	14	8	22	16	8	22	18	8
																8

North Declination.

North Declination.

JULY XXXI Days.

Leap ye.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Day Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising and Sett.			Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	G	24		8	3	4	22	4		22	6		22	8		22	10	
2	A	23	1	☉	20	♋.	21	56	8	21	58	8	22	00	8	22	2	8
3	B	22	14	8	2	4	21	47	9	21	49	9	21	51	9	21	54	9
4	C	21		8	1	4	21	38	9	21	40	9	21	42	9	21	45	9
5	D	20	10	8	0	4	21	28	10	21	31	10	21	33	9	21	35	10
6	E	19		7	58	5	21	18	10	21	21	10	21	23	10	21	26	9
7	F	18	0	7	57	5	21	8	10	21	11	11	21	13	10	21	16	10
8	G	17	19	7	56	5	20	57	11	21	00	11	21	3	10	21	5	11
9	A	16		7	55	5	20	46	11	20	49	12	20	52	11	20	54	11
10	B	15	8	7	54	5	20	34	12	20	37	11	20	40	12	20	43	11
11	C	14	4	7	53	5	20	23	11	20	26	12	20	29	11	20	31	12
12	D	12	17	7	52	5	20	11	12	20	14	12	20	17	12	20	20	11
13	E	*		☉	in	♌.	19	59	12	20	2	13	20	5	12	20	8	12
14	F	11	5	7	49	5	19	46	13	19	49	13	19	52	13	19	55	13
15	G	10		Swithin.			19	33	13	19	36	13	19	39	13	19	42	13
16	A	9	1	7	46	5	19	20	13	19	23	13	19	26	13	19	24	13
17	B	7	14	7	45	5	19	6	14	19	10	14	19	13	13	19	16	13
18	C	*		7	43	5	18	52	14	18	56	14	18	59	14	19	2	14
19	D	6	10	*Dog d. begin.*			18	30	14	18	42	15	18	45	14	18	48	14
20	E	5		7	40	5	18	23	15	18	27	15	18	30	15	18	34	14
21	F	4		7	39	5	18	8	15	18	12	15	18	15	15	18	19	15
22	G	3	11	Magdalen.			17	53	15	17	57	16	18	00	15	18	4	15
23	A	2		☉	10	♌.	17	37	16	17	41	16	17	45	15	17	49	15
24	B	1	8	7	34	4	17	21	16	17	25	16	17	29	16	17	23	16
25	C	29	20	S. James Ap.			17	5	16	17	9	16	17	13	16	17	17	16
26	D	28	14	7	0	5	16	49	16	16	53	16	16	57	16	17	1	16
27	E	27		7	29	5	16	33	16	16	37	17	16	41	16	16	45	16
28	F	26	5	7	27	5	16	16	17	16	20	17	16	24	17	16	28	17
29	G	*		7	25	5	15	59	17	16	3	18	16	7	17	16	11	17
30	A	25	1	7	24	5	15	41	18	15	45	18	15	50	17	15	54	17
31	B	23	14	7	22	5	15	23	18	15	27	18	15	32	18	15	36	18

North Declination. *North Declination.*

AUGUST XXXI Days.

Leap yr.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Da. Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising. and Sett.			Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	C	*		Lammas.			15	5		15	10		15	14		15	19	
2	D	22	3	7	19	5	14	47	18	14	52	18	14	56	18	15	1	18
3	E	21	0	☉	20	♌.	14	29	18	14	34	18	14	38	18	14	42	19
4	F	20	0	7	16	7	14	10	19	14	15	19	14	19	19	14	24	18
5	G	18	12	7	14	7	13	51	19	13	56	19	14	00	19	14	5	19
6	A	*		7	12	7	13	32	19	13	37	19	13	41	19	13	46	19
7	B	17	8	7	10	7	13	13	19	13	18	19	13	52	19	13	27	19
8	C	15	20	7	8	7	12	54	19	12	59	19	13	3	19	13	08	19
9	D	14	17	7	7	7	12	34	20	12	39	20	12	43	20	12	48	20
10	E	13		Laurence.			12	14	20	12	19	20	12	23	20	12	28	20
11	F	12	5	7	3	5	11	54	20	11	59	20	12	3	20	12	8	20
12	G	11	18	7	1	5	11	33	21	11	38	21	11	43	20	11	48	20
13	A	10		☉	in	♍.	11	13	20	11	18	21	11	23	20	11	28	20
14	B	9	14	6	58	6	10	52	21	10	57	21	11	3	20	11	7	21
15	C	8		6	56	6	10	32	20	10	36	21	11	42	21	10	47	20
16	D	7	3	6	54	6	10	11	21	10	15	21	10	21	21	10	26	21
17	E	*		6	52	6	9	50	21	9	54	21	10	00	21	10	5	21
18	F	6	0	6	50	6	9	28	22	9	33	21	9	38	22	9	44	21
19	G	4	12	6	48	6	9	6	22	9	12	22	9	17	21	9	22	22
20	A	*		6	46	6	8	44	21	8	50	21	9	55	22	9	1	21
21	B	3	0	6	44	6	8	23	22	8	29	22	8	33	22	8	39	22
22	C	1	12	6	42	6	8	1	22	8	7	22	8	12	21	8	17	22
23	D	*		☉	10	♍.	7	39	22	7	45	22	7	50	22	7	55	22
24	E	29	9	Barthol.			7	17	22	7	23	23	7	28	22	7	33	22
25	F	28	5	6	36	6	6	56	23	7	00	23	7	5	23	7	11	22
26	G	26	18	6	34	6	6	32	22	6	38	22	6	43	22	6	45	23
27	A	*		6	32	6	6	10	23	6	15	23	6	21	22	6	26	22
28	B	25	14	*Dog. d. end*			5	47	22	5	53	22	6	58	23	6	4	22
29	C	24	6	6	29	6	5	25	23	5	30	23	5	35	23	5	41	23
30	D	23	3	6	27	6	5	2		5	8	22	5	13	22	5	18	23
31	E	22	15	6	25	6	4	39	27	4	44	24	4	52	23	4	55	23

North Declination.

North Declination.

SEPTEMBER XXX Days.

Leap ye.	First.	Second.	Third.
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

North Declination.

Day Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising and Sett.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	F	21		Giles.	4	16		4	22		4	27		4	32	
2	G	20	12	6 21 6	3	53	23	3	59	23	4	4	23	4	9	23
3	A	19		☉ 20 ♍.	3	30	23	3	35	24	3	41	23	3	46	23
4	B	18	0	6 17 6	3	7	23	3	12	23	3	17	24	3	23	23
5	C	17	20	6 15 6	2	43	24	2	49	23	2	54	23	3	00	23
6	D	16		6 13 6	2	20	23	2	26	23	2	31	23	2	37	23
7	E	15	9	6 12 6	1	57	23	2	3	23	2	8	23	2	13	24
8	F	14	6	Lady Fair.	1	33	24	1	39	24	1	45	23	1	50	23
9	G	12	18	6 7 6	1	10	23	1	16	23	1	21	24	1	27	23
10	A	*		6 5 6	0	46	24	0	52	24	0	58	23	1	3	24
11	B	11	7	6 3 6	0	23	23	0	29	23	0	30	24	0	40	24
12	C	10		6 1 6	0	1	22	0	5	24	0	10	24	0	16	24
13	D	9	3	☉ in ♎.	South	24	23	South	18	24	South	13	7	South	7	9 Æquinoctial
14	E	7	16	5 57 7	0	48	24	0	42	23	0	36	23	0	31	24
15	F	*		5 55 7	1	11	23	1	5	24	1	00	26	0	54	23
16	G	6	12	5 53 7	1	35	24	1	29	24	1	23	23	1	18	24
17	A	5		5 51 7	1	58	23	1	52	23	1	47	24	1	41	23
18	B	4		5 49 7	2	22	24	2	16	24	2	10	23	2	5	24
19	C	3		5 47 7	2	45	23	2	40	24	2	34	24	2	28	23
20	D	2		5 45 7	3	9	24	3	3	23	2	57	23	2	52	24
21	E	1	9	Matth. Ap.	3	32	23	3	27	24	3	21	24	3	15	23
22	F	29	22	5 42 7	3	56	24	3	50	23	3	44	23	3	38	23
23	G	28	18	☉ 10 ♎.	4	19	23	4	13	23	4	7	23	4	2	24
24	A	27		5 38 7	4	42	24	4	36	23	4	30	23	4	25	23
25	B	26	17	5 36 7	5	6	23	4	59	23	4	54	24	4	48	23
26	C	*		5 34 7	5	29	23	5	23	24	5	17	23	5	12	24
27	D	25	3	5 32 7	5	52	23	5	36	23	5	41	24	5	35	23
28	E	23	16	5 30 7	6	15	23	6	09	23	6	4	23	5	58	23
29	F	*		Michael.	6	38	23	6	32	23	6	16	22	6	21	23
30	G	22	4	5 26 7	7	1	23	6	55		6	49	23	6	44	23

South Declination.

OCTOBER XXXI Days.

Leap ye.	*First.*	*Second.*	*Third.*
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1783
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

Da. Mo.	*Da. Week*	☽ *Epact.*	*Hour.*	☉ *Rising. and Sett.*			*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	A	21		5	24	7	7	24		7	17		7	12		7	06	
2	B	20	0	5	22	7	7	46	22	7	40	23	7	35	22	7	29	23
3	C	18	13	☉	20	♎.	8	9	23	8	2	22	7	58	23	7	52	23
4	D	*		5	18	7	8	31	22	8	25	23	8	20	22	8	15	23
5	E	17	9	5	16	7	8	53	22	8	47	22	8	42	22	8	37	22
6	F	22	22	5	14	7	9	15	22	9	9	22	9	4	22	8	59	22
7	G	14	18	5	12	7	9	37	22	9	32	23	9	27	23	9	21	22
8	A	13		5	10	7	9	59	22	9	54	22	9	49	22	9	43	22
9	B	12	7	5	8	7	10	21	22	10	16	22	10	10	21	10	5	22
10	C	11	19	5	6	7	10	43	22	10	37	21	10	32	22	10	27	22
11	D	10		5	4	7	11	04	21	10	59	22	10	53	21	10	48	21
12	E	9	16	5	2	7	11	25	21	11	20	21	11	15	22	11	10	22
13	F	8		☉	in	♏.	11	46	21	11	41	21	11	36	21	11	31	21
14	G	7	4	4	59	8	12	7	21	12	2	21	11	57	21	11	52	21
15	A	*		4	57	8	12	28	21	12	23	21	12	18	21	12	13	21
16	B	6	0	4	55	8	12	48	20	12	44	21	12	39	21	12	34	21
17	C	4	13	4	53	8	13	9	21	13	4	20	12	59	20	12	54	20
18	D	*		Luke.			13	29	20	13	24	20	13	20	21	13	14	20
19	E	3	1	4	49	8	13	49	20	13	44	20	13	40	20	13	34	20
20	F	2					14	9	20	14	4	20	13	59	19	13	54	20
21	G	1	0				14	28	19	14	24	20	14	19	20	14	14	20
22	A	29	11				14	48	20	14	43	19	14	38	19	14	34	20
23	B	28	7	*Term begins.*			15	7	19	15	2	19	14	57	19	14	53	19
24	C	26	19	4	40	8	15	26	19	15	21	19	15	16	19	15	12	19
25	D	*		Crispin.			15	44	18	15	40	19	15	35	19	15	31	19
26	E	25	16	☉	13	♏.	16	2	18	15	58	18	15	53	18	15	49	18
27	F	24					16	20	18	16	16	18	16	11	18	16	7	18
28	G	23	4	Sim. Jude			16	38	17	16	33	17	16	29	18	16	25	18
29	A	22	17				16	55	17	16	51	18	16	45	18	16	32	17
30	B	21					17	12	17	17	8	17	17	4	17	17	00	18
31	C	20	13	4	2	8	17	29	17	17	25	17	17	21	17	17	17	17

South Declination.

South Declination.

NOVEMBER XXX Days.

	Leap ye.	*First.*	*Second.*	*Third.*
	1696	1697	1698	1699
	1700	1701	1702	1703
	1704	1705	1706	1707
	1708	1709	1710	1711
	1712	1713	1714	1715
	1716	1717	1718	1719
	1720	1721	1722	1723
	1724	1725	1726	1727
	1728	1729	1730	1731
	1732	1733	1734	1735

The Sun's Declination.

Day Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising and Sett.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	D	19		All Saints.	17	46		17	41		17	38		17	32	
2	E	18	2	All Souls.	19	2	16	17	58	17	17	54	16	17	50	17
3	F	*			18	18	16	18	14	16	18	10	16	18	6	16
4	G	17	00		18	33	15	18	30	16	18	26	16	18	22	16
5	A	15	11	Powder Tr.	18	48	15	18	45	15	18	41	15	18	37	15
6	B	14	7		19	3	15	19	00	15	18	56	15	18	53	16
7	C	12	19	4 61 8	19	18	15	19	14	15	19	11	15	19	8	15
8	D	*		☉ 25 ♏.	19	32	14	19	29	14	19	25	14	19	22	14
9	E	11	8	4 15 8	19	46	14	19	43	14	19	39	14	19	36	14
10	F	8		4 13 8	19	59	13	19	56	13	19	53	14	19	50	14
11	G	9	04	Martin.	20	13	14	20	10	14	20	06	13	20	3	13
12	A	7	17		20	26	13	20	23	13	20	19	13	20	16	13
13	B	*			20	38	12	20	33	12	20	31	12	20	29	13
14	C	6	13		20	50	12	20	47	12	20	43	12	20	41	12
15	D	5			20	2	10	20	59	12	20	55	12	20	53	12
16	E	4	2	☉ 4 ♐.	21	13	11	21	10	11	21	7	12	21	5	12
17	F	3	14	4 3 8	21	23	10	21	21	11	21	18	11	21	16	11
18	G	2			21	34	11	21	31	10	21	29	11	21	26	10
19	A	1	11		21	44	10	21	41	10	21	39	10	21	36	10
20	B	29	23		21	54	10	21	51	10	21	49	10	21	46	10
21	C	28	20		22	3	9	22	00	9	21	58	9	21	56	10
22	D	27		☉ 10 ♐.	22	11	8	22	09	9	21	7	9	22	5	9
23	E	26	8	3 56 9	22	20	9	22	18	9	22	16	9	22	13	8
24	F	*		3 55 9	22	28	8	22	26	8	22	24	8	22	22	9
25	G	25	4		22	35	7	22	34	8	22	31	7	22	30	8
26	A	23	17		22	42	7	22	41	7	22	39	8	22	37	7
27	B	*			22	48	6	22	48	7	22	45	6	22	44	7
28	C	22	6	Term ends.	22	54	6	22	54	6	22	52	7	22	50	6
29	D	21		3 51 9	23	00	6	22	59	5	22	58	6	22	56	6
30	E	20	2	Andrew.	23	05	5	23	4	5	23	3	5	23	2	6

South Declination.

South Declination.

DECEMBER XXXI Days.

Leap ye.	*First.*	*Second.*	*Third.*
1696	1697	1698	1699
1700	1701	1702	1703
1704	1705	1706	1707
1708	1709	1710	1711
1712	1713	1714	1715
1716	1717	1718	1719
1720	1721	1722	1723
1724	1725	1726	1727
1728	1729	1730	1731
1732	1733	1734	1735

The Sun's Declination.

South Declination.

Da. Mo.	*Da. Week*	☽ *Epact.*	*Hour.*	⊙ *Rising. and Sett.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	F	18	15	⊙ 20 ♐.	23	10		23	9		23	08		23	6	
2	G	*		3 50 9	23	14	6	23	13	4	23	12	4	23	11	5
3	A	17	11	3 49 9	23	18	4	23	17	4	23	16	4	23	15	4
4	B	15	23	3 48 9	23	21	3	23	20	3	23	20	4	23	19	4
5	C	14	20	3 48 9	23	24	3	23	23	3	23	23	3	23	22	3
6	D	13		3 48 9	23	26	2	23	26	3	23	25	3	23	25	3
7	E	12	8	3 47 9	23	28	2	23	28	2	23	27	2	23	27	2
8	F	11	21	*Days are at*	23	30	2	23	29	1	23	29	2	23	28	1
9	G	10		*a stand.*	23	31	1	23	30	1	23	30	1	23	30	2
10	A	9	17		23	31	0	23	31	1	23	31	1	23	31	1
11	B	8		⊙ in ♑.	23	31	0	23	31	0	23	31	0	23	31	0
12	C	7	6	*Days in-*	23	30	1	23	31	0	23	31	0	23	31	0
13	D	*		*crease.*	23	29	1	23	30	1	23	30	1	23	30	1
14	E	6	2	3 47 9	23	28	1	23	29	2	23	29	1	23	29	1
15	F	4	15	3 47 9	23	26	2	23	27	2	23	27	2	23	27	2
16	G	*		3 48 9	23	24	2	23	25	2	23	25	2	23	25	2
17	A	3	3	3 48 9	23	21	3	23	22	3	23	22	3	23	23	2
18	B	2		3 49 9	23	18	3	23	19	3	23	19	3	23	20	3
19	C	1	0	3 49 9	23	14	4	23	15	4	23	16	4	23	16	4
20	D	29	12	⊙ 9 ♑.	23	9	5	23	10	5	23	12	4	23	12	4
21	E	28	8	Thomas.	23	5	4	23	6	6	23	7	5	23	8	5
22	F	27		3 50 9	23	00	5	23	1	6	23	2	5	23	3	5
23	G	26		3 51 9	22	54	6	22	55	6	23	57	5	22	54	5
24	A	25	17	3 52 9	22	48	6	22	49	7	23	51	6	22	52	6
25	B	74		Christmas.	22	41	7	22	43	8	22	45	6	22	46	6
26	C	23	6	Stephen.	22	34	7	22	36	8	22	38	7	22	39	5
27	D	22	18	John.	22	27	7	22	21	8	22	31	7	22	32	7
28	E	21		Innocents.	22	19	8	22	20	8	22	23	8	22	25	7
29	F	20	15	3 56 9	22	11	8	22	12	8	22	15	8	22	17	8
30	G	19		3 57 9	22	9	8	22	4	9	22	6	9	22	8	5
31	A	18	3	3 58 9	21	53	6	21	55	9	21	57	9	21	59	9

South Declination.

The Use of the Kalender.

To find the Sun's Declination upon every day of the Year.

THe Sun's Year (that is, the time that the Sun goeth out of a certain Point of the Ecliptick, and returneth again to the same) is not of 365 days just; but about 5 h. and 49 min. more (that is, little less than 6 hours;) wherefore after 3 Years, there is always added to the 4th 4 times 6 hours, that is, a day more in *February*, for to coun the Year or the Revolution of the Sun in even days; therefore that 4th Year is called Leap-Year: wherefore when we describe the Sun's Declination in Tables, we always use to make 4 several Tables, for 4 such Years following one the other; and yet by reason of the aforesaid difference, that 4 Revolutions of the Sun do not justly make up one day, but wants about 44 min. bringeth in process of time so great a difference in the Declination, that it is needful every 20 Years to renew such Tables. How to find the Leap-years, it is thus: Divide the Year of our Lord above 1600 by 4; if the Division doth fall out even without any overplus, that Year then is a Leap-year of 366 days: But if out of the Division there remain any Number, that remainder sheweth how many Years that Year propounded is after the Leap-year. I desire to know what Year the 1666 is. Leaving 1600, I divide 66 by 4, and there remains 2; whereby I find the Year 1666 to be the second Year after the Leap-year. In like manner work for any other Years. It is required to know what Year 1692 is. Leaving the 1600, divide the 92 by 4, and 0 remains upon the Division; wherefore I find that 1692 is a Leap-year. For to know the same by the foregoing Tables, is thus. Each Month hath 12 Columns; the first thereof shews the days of the Month; the second, having the Dominical Letters, shews the days of the Week; the third having two Rows of Figures, the first of them shews the Epact of the Moon, and the other the Hour of the Day, reckoning the said Hours always from Noon; the 4th shews the chief Days of the Year, Terms beginning and ending; and in the void places it shews the Rising and Setting of the Sun in this Latitude, and the Place of the Sun every 10th day. These 4 Columns of themselves are fit for ordinary use, and may with a little Pains perform the uses of the yearly Almanacks, as you shall see by the following Rules. The 5th Column of the foregoing Tables shews the Sun's Declination for every day of the Year, for all these Years in the first Column under-written, which are all Leap-years. The 6th shews the daily difference of the Sun's Declination. The 7th shews it for the first Year from the Leap-year. The 8th the daily difference of the Sun's Declination in that Year. The 9th shews the second Year from the Leap-year; the 10th the difference; the 11th the third Year from the Leap-year; the 12th the difference. The foregoing Tables are Calculated for the Meridian of *London*, &c.

Of the difference of the Declination in divers places of the Earth.

NOte this, they that are more Easterly from the Meridian of *London* have the Declination less when the Declination increaseth either Northward or Southward; and when the Sun's Declination decreaseth, it is greater.

On the contrary, they that are more Westerly from the Meridian of *London*, when the Declination increaseth North or South, have more Declination, and less when the Declination decreaseth.

A Table by which you may proportion the Sun's Declination to any other Meridian.

The Difference in Declination daily		M. 00	M. 03	M. 06	M. 09	M. 12	M. 15	M. 18	M. 21	M. 24
		M.	M.	M.	M.	M.	M.	M.	M.	M.
Deg.	15	0	0	0	0	0	0	1	1	1
	30	0	0	0	0	1	1	1	2	2
	45	0	0	0	1	1	2	2	3	3
Degrees of	60	0	0	1	1	2	2	3	3	4
Difference of	75	0	0	1	2	2	3	4	4	5
Longitude	90	0	0	1	2	3	4	4	5	6
either East	105	0	1	2	2	3	4	5	6	7
or West.	120	0	1	2	3	4	5	6	7	8
	135	0	1	2	3	4	5	7	8	9
	150	0	1	2	3	5	6	8	9	10
	165	0	1	2	4	5	6	8	10	11
	180	0	1	3	4	6	7	9	11	12

Examp.

360.24.110
24
440
220
2640
161
24. 23. 7.
7
161
24

Examp. On the 26th of *March*, the first Year after the Leap-year, I desire to know the Declination of the Sun at Noon at *Bantam* in the *East-Indies*. I find by Globes or the Plat of *Mercator*, that *Bantam* is to the Eastward of the *Meridian* of *London* about 110 deg. (we do not esteem of a deg. or two, because it amounteth to nothing in this business.) Say, If one Revolution of the Sun, which is 360 deg. requires 24 hours, what time will 110 degrees? *Facit* 7 hours, and something more, whereby the Sun comes to the *Meridian* 7 hours sooner at *Bantam*, than it doth at *London*: so that it is 12 a Clock at Noon at *Bantam*, when it is 4 of the Clock in the morning with us at *London*. The Sun's Declination for the 26th of *March*, is 6 deg. 25 min. The difference of the Declination of the day following you find is 23 min. which it is increasing. Therefore I say if in 24 hours the Declination increaseth 23 min. how much then in 7 hours? *Facit* almost 7 min. that the Declination is less than it is at *London*. So that the Declination at *Bantam* that day is but 6 deg. 18 min. North.

Examp. 2. *By the foregoing Table.*

On the 17th of *September* in the same Year, I desire to know the Declination that day at Noon at *Bantam*. The Declination for the *Meridian* of *London* is that day 1 deg. 52 min. and the difference of the Declination of the day following is 24 min. decreased; and, as was said before in the last *Example*, the difference of Longitude is 110 deg. Therefore I look in the Head of the foregoing Table, for the nearest Number to the difference 24, and find it to fall on the Head of the last Column; then look on the left hand of the Table for the difference of Longitude, and I find 105 deg. nearest, and in the Common Angle of meeting I find 7, which is to be subtracted from the Declination in the *Meridian* of *London* abovesaid, 1 deg. 52 min. and the remainder will be the Declination for the *Meridian* or *Longitude* I am in, which is 1 deg. 45 min. South. But if the Declination decreaseth, as it doth here increase, then you must have added.

	deg.	min.	
In the *Meridian* of *London* the Declination	01	52	
The minutes proportional subtracted	00	07	
The Declination for 110 deg. Longitude of *Bantam*, East	01	45	
The Declination of 110 deg. West of the *Meridian* of *London*	01	59	West.

Examp. 3. A Ship being come on the 7th of *November*, in the third Year after the Leap-year, into the great South Sea, thwart of the Coast of *Peru*, in Longitude 76 deg. from *London*. The Pilot desireth the Declination there at Noon in that *Meridian*.

	deg.	min.	
In the *Meridian* of *London* the Declination is	19	08	South
The minutes proportional added	00	03	
In the Longitude 76 deg. the Declination	19	11	West.
In the Longitude of 76 deg. East, the Declination is	19	05	

The Refraction of the *Sun*, *Moon*, and *Stars*, causeth them to appear higher above the Horizon than they are: therefore the Refraction is always to be subtracted from the Altitude observed, that the true Altitude may be had.

Example.

The Sun's *Meridian Altitude* by Observation being 90 deg. I require the true Altitude.

	deg.	min.
Altitude by Observation	09	00
Refraction subtract	00	10
The true *Meridian Altitude*	08	50

A Table of the Refractions of the Sun, Moon, and Stars, according to the Observation of the thrice Noble Tycho Brahe.

Altitude.	*Sun. min.*	*Moon min.*	*Stars min.*	*Altitude.*	*Sun. min.*	*Moon min.*
0	34	33	30	18	06	06
1	26	25	21	19	05	06
2	20	20	15	20	04	05
3	17	17	12	21	04	05
4	15	15	11	22	03	04
5	14	14	10	23	03	04
6	13	14	09	24	03	04
7	12	13	08	25	02	03
8	11	12	07	26	02	03
9	10	11	06	27	02	03
10	19	10	05	28	02	02
11	09	10	05	29	02	01
12	09	10	04	30	01	02
13	08	09	04	31	01	02
14	08	08	03	32	01	01
15	07	08	03	33	01	01
16	07	07	02	34	01	01
17	06	07	02	35	01	01

By reason of the Refraction of the *Sun*, a Dutch Ship being upon the discovery of a *North-East* Passage to the *East-India*, and Winter being in *Nova Zembla*; the Mariners beheld the *Sun* 17 days sooner than he should by his Declination appear above the Horizon, which is caused by the gross Vapours, and thickness of the Air near the Horizon.

I. *To know the day of the Month.*

THis is the Chief Use of an Almanack, and may as well be performed by this, as by any other. To this purpose you must by the general Kalender at the beginning hereof, know the *Dominical* or *Sunday-Letter* for the Year; then considering with your self whether it be the beginning, midst, or end of the month, (as you must do in any Almanack) find this Letter in the beginning, midst, or end of the month, and reckoning from it to the day of Week, either *Monday* or *Tuesday*, or whatsoever other day it is; right against the day of the Week, you shall find what day of the month it is. Here is no difficulty in this; only when it is Leap-year you see there is two *Sunday-Letters*, the first of these you must use only to the 24th of *February*, and the other all the Year after. *Example.* In 1668. the *Dominical Letters* E D the first *Sunday* in *January*, is at the first E, which is at the fifth day of the month; the first *Sunday* in *February* is at the second day of the month; but the first *Sunday* in *March* is at the first D, which is at the first day of the month, and so all the year after.

II. *To know what day of the Week any Notable day will fall upon in any Year.*

FIrst, find the *Dominical Letter* in the former Table; then find your Letter in your Month next before the day you desire, and so from thence count the days of the Week, till you come to the day desired. Thus if you would know what day of the Week *Lady-day* falls upon in the Year 1668. the *Dominical Letter is* D; this is three days before the said day, therefore it falls upon a *Wednesday*. But in the Year 1669. when the *Dominical Letter* is C, *Lady-day* will be upon *Thursday*.

III. *To find the time of Sun-rising and Setting.*

THis is set down for most of the days in the Year, for *London*; and may serve for most parts of *England*: And this is done after somewhat a briefer manner than is usual, making the minutes which is placed in the midst, to serve both the hours of Setting and Rising; which you must understand thus: The 7th of *February* you shall find these Figures, 4, 59, 8, that is, the *Sun* that day sets at 4 h. 59 min. that is, 59 min. after 4, and riseth at 59 m. 8 h. that is 59 m. before 8, or at 1 min. past 7 a Clock. And so you must account them always, remembring, that as the minutes follow the first Figure, so they must be reckoned in time after it; as they stand before the last Figure, so they must be reckoned in time before it.

If

	ho.	min.
If you double this time of Sun-setting	04	59
You have the length of the Day	09	58
If you subtract it from	12	00
You have the time of Rising	07	01
And this doubled shews the length of the Night	14	02

IV. *To find the Place of the Sun.*

THis is set down in the Kalendar about every tenth day; so that reckoning a degree for each day between, you shall have the place of the *Sun* exact enough for most ordinary Uses. Thus the 10th of *March* the *Sun* enters into *Aries*; therefore the 15th day, or five days after, the *Sun* is in five degrees of *Aries*.

V. *To find the Day and Hour of the New Moon, and thereby the Full and Quarters.*

FIrst you must find the *Moons Epact* for the present Year you are in: This Number is found out in the First Book, and also the Table at the beginning of the Kalendar. The Change also may be found out by the *Golden Number*: But it is much readier to find out by this *Epact*, which runs for the most part in a constant Order, only here and there skipping a day, and is marked thus, *

Having found out the *Epact* for this present Year, turn to the Month you desire, and there find out the said Number of the *Epact* in the third Column of the Months, and mark what day of the Month it stands against, for that is the day of the Change or New Moon. Likewise if you have respect to the *Dominical Letter*, which is by it, you shall see what day of the Week it is. Now here in this Column there are two Rows of Figures; the first shews the *Epact-Number*, and the next the Time of the Day reckoned by the hours from Noon, which are plain to understand till you come to 12 hours after Noon, which is Mid-night; but then the Numbers above 12, you must reckon to the Morning of the next day.

So that these hours after Noon, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, are all one with these at Noon the next day in the Morning, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.

Thus in the Year 1666. the *Epact* being 4, and the *Dominical Letter* G, you shall find this *Epact-Number* 4 in the month of *July*, against the 21th day, being *Saturday*; and the Cipher o standing by it, shews that the *New Moon* is just at Noon. Again in the month of *November*, you shall find the *Epact* 4, against the 16th day being *Friday*; and the Figure of 2 standing by it, shews that about 2 hours after Noon the *Moon* changeth. Having first found the time of the *New Moon*, you may from thence reckon the Age of the *Moon*, and find the Quarters and *Full Moon*. Thus the *Moons* Age is, at the First Quarter 7 days; at the *Full Moon* 15; at Last Quarter 22 days.

The End of the Second Book.

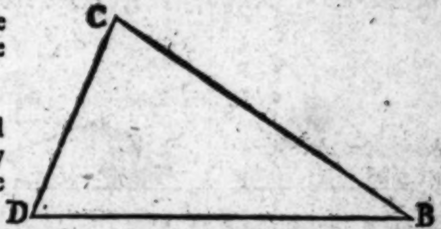
The Third Book.

CHAP. I. *Of the Affection of Right-lin'd Triangles.*

THis Third Book is as it were a Key to these that follow, the Subject whereof is Trigonometry; therefore its convenient before I come to the following Practise, to say something concerning Plain and Spherical Triangles, although that Subject be handled by divers able Mathematicians already; as *Norwood* and others: so that those who desire to make a further scrutiny into Trigonometry: may peruse them.

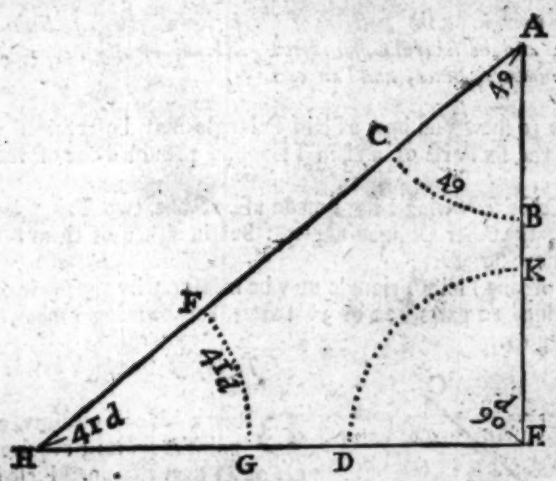
Before we come to shew how the Quantity of the Sides and Angles of any Triangle may be found by the Tables of Artificial Sines, Tangents, and Logarithms, and by the Lines of Artificial Sines, Tangents, and Numbers, take these following Theorems, as necessaries thereunto.

I. A Triangle is a Figure consisting of three Sides, and three Angles, as in the Figure DBC.



II. Any two Sides of a Triangle, are called the Sides of the Angle comprehended by them; as the Sides CB and DB, are the Sides containing the Angle CBD.

III. The Measure of an Angle is the Quantity of an Arch of a Circle, described on the Angular Point, and cutting both the containing sides of the same Angle: As in the Triangle following, the Arch CB is the Measure of the Angle at A, the Arch KD is the measure of the Angle at E, and the Arch FG is the measure of the Angle at H. Each of these Arches are described on the Angular Points A, H, E, and cut the containing Sides.



IV. A Degree is the 360 part of a Circle.
V. A Semicircle containeth 180 Degrees.
VI. A Quadrant containeth 90 Degrees.
VII. The Complement of an Angle less than a Quadrant, is so much as that Angle wanteth of 90 Degrees; as if the Angle AHE should contain 41 Degrees, the Complement thereof would be 49 deg. For if you take 41 from 90, there will remain 49 deg.
VIII. The Complement of an Angle to a Semicircle, is the Remainder thereof to 180 Degrees.
IX. An Angle is either Right, Acute, or Obtuse.
X. A Right Angle is that whose measure is a Quadrant.
XI. An Acute Angle is less than a Right Angle.
XII. An Obtuse Angle is greater than a Quadrant.

XIII. A

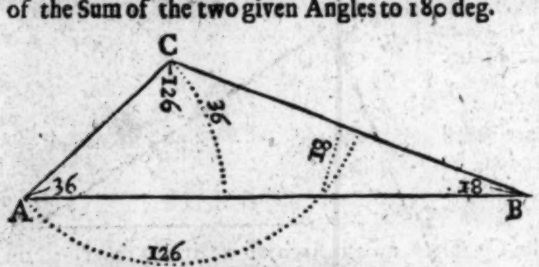
XIII. A Triangle is either Right-angled, or Obtuse-angled.

XIV. A Right-angled Triangle is that which hath one Right-angle; as the Triangle A H E is Right-angled at E.

XV. In every Right-angled Triangle, that Side which subtendeth (or lieth opposite to) the Right-angle, is called the Hypothenusa; and of the other two sides, the one is called the Perpendicular, and the other the Base at pleasure: But most commonly the shortest is called the Perpendicular, and the longer is called the Base. So in the former Triangle, the side A H is the Hypothenusa, H E the Base, and A E the Perpendicular.

XVI. In every Right-angled Triangle, if you have one of the Acute Angles given, the other is also given, it being the Complement thereof to 90 deg. As in the Triangle A H E, suppose there were given the Angle H A E 49 deg. then by consequence the Angle A H E must be 41 degrees, which is the Complement of the other to 90 degrees.

XVII. The three Angles of any Right-lined Triangle whatsoever, are equal to two Right Angles, or to 180 degrees: so that if of any Right-lined Triangle, you have any two of the Angles given, you have the third Angle also given, it being the Complement of the Sum of the two given Angles to 180 deg.



So in this Triangle A B C, if there were given the Angle B A C 36 degrees, and the Angle A C B 126 Degrees, I say by the consequence, there is also given the third Angle. For if you add the two given Angles together and subtract the Sum from 180 degrees, there will remain A B C 18 degrees.

In all plain Triangles, the Sides are in such proportion one to the other, as the Sines of the Angles opposite to those Sides. So in the Triangle A B C, the Sine of the Angle A C B is in such proportion to the Side A B, as the Sine of the Angle C A B is to the Side B C. And so of any other.

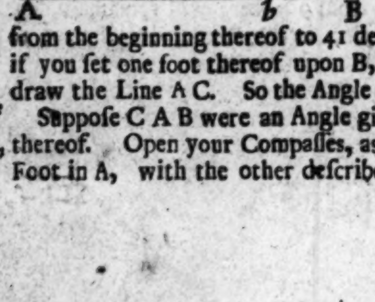
CHAP. II. *Containing the Doctrine of Right-lined Triangles, both Right-angled and Oblique-angled; and the several Cases therein resolved, both by Tables, and also by the Lines of Artificial Numbers, Sines, and Tangents.*

I Come now to shew you how a Plain Triangle may be resolved; that is, by having three of the six Parts of a Plain Triangle, provided one of them be a Side, to find a fourth.

In all the Cases following I have made use of but two Triangles for Examples; one Right-angled, the other Oblique-angled: but in either of them I have expressed all the Varieties that are necessary.

The Sides of any Plain Triangle may be measured by any Scale of Equal Parts; as an Inch divided into 10 parts, 20 or 30 Parts, representing Inches, Feet, Yards, Poles, Miles, or Leagues.

To lay off an Angle by the Line of Chords.



DRaw a Line at pleasure, as A B; and from the point A let it be required to protract an Angle of 41 deg. 24 min. First extend the Compasses upon the Line of Chords, from the beginning thereof to 60 deg. always; and with this distance setting one foot upon the point A, with the other describe the pricked Arch B C: Then with your Compasses take 41 d. 24 m. (which is the quantity of the inquired Angle) out of the Line of Chords, from the beginning thereof to 41 deg. 24 min. Keeping the Compasses at this distance, if you set one foot thereof upon B, the other will reach upon the Arch to C. Lastly, draw the Line A C. So the Angle C A B shall contain 41 deg. 24 min.

To find the Degrees contained in an Angle. Suppose C A B were an Angle given, and that it were required to find the Quantity thereof. Open your Compasses, as before, to 60 deg. of your Chord; and placing one Foot in A, with the other describe the Arch B C. Then take in your Compasses the distance

distance C B, and measuring that extent upon the Line of Chords, from the beginning thereof, you shall find it reach 41 degrees ; which is the Quantity of the inquired Angle.

If any Angle given or required shall contain above 90 degrees, you must then measure it at twice, by taking first the Chord of 90 deg. and then the Remainder.

The several Cases of Right-lin'd Triangles, may not only be applied to Navigation, but also in the taking of Heights, as is shewn elsewhere.

In the resolving of Plain Triangles there are 12 Cases, on which I will insist in their order.

CHAP. III. *Of Right-angled Plain Triangles.*

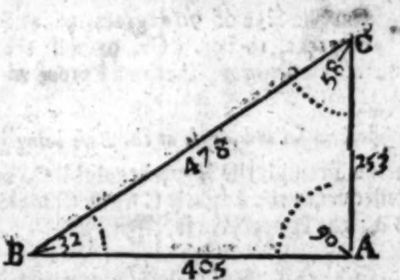
CASE I. *In a Right-angled Plain Triangle, the Base and the Angle at the Base being given, to find the Perpendicular.*

Suppose that the Line C A (in the following Figure) in the Right-angled Triangle were a Tree, Tower, or Steeple, and that you would know the Height thereof; you must observe with your Instrument the Angle C B A, and measure the Distance B A. So have you in the Right-angled Triangle A B C, the Base 405 Foot, and the Angle at the Base 32 deg. and it is required to find the Perpendicular A C. Now because the Angle C B A is given, the Angle B C A is also given, it being the Complement of the other to 90 deg. and therefore the Angle B C A is 58 degrees: Then to find the Perpendicular C A, the Proportion is,

As the Sine of the Angle B C A 58 deg.	9928420
Is to the Logarithm of the Side B A 405 Foot	2607455
So is the Sine of the Angle C B A 32 deg.	9724210
The Sum of the second and third added	12331665
The first Number subtracted from that Sum	9928420
To the Logarithm of the Side C A	2403245

The Number answering to this Logarithm 2403245, is 253 Feet, and that is the length of the Side C A, or the Height of the Tree, Tower, or Steeple, which was required.

A General Rule. In all Proportions wrought by the Logarithms, you must observe this for a general Rule, (*viz.*) To add the second and third Numbers together, and from the Sum of them to subtract the first Number, so shall the Remainder answer your Question demanded. As by the former Work you may perceive, where the Logarithm of the Side B A 2607455 (which is the second Term) is added to the Sine of the Angle C B A 9724210 (which is the third Term) and from the Sum of them, namely from 1233 1665, is subtracted 9928420, the Sine of the Angle B C A, which is the first Number, and there remaineth 2,403245, which is the Logarithm of 253, and that is the Length of the side required.



To resolve the same Work by the Line of Sines and Numbers.

You may work these Proportions by the help of the Line of Sines, Tangents, and Numbers, on your Scale, the Proportion being as before.

Therefore if you set one Foot of your Compasses at 58 deg. in the Line of Sines, and extend the other Foot to 405 in the Line of Numbers, the same will reach from the Sine of 32 deg. 253 in the Line of Numbers, which is the length of the side A C; which was required.

An Or

Or otherwise, Extend the Compasses from the Sine of 58 deg. to the Sine of 32 deg. in the Line of Sines; the same Extent will reach from 405 in the Line of Numbers, to 253, as before.

CASE. II. *The Base and the Angle at the Base given, To find the Hypothenusa.*

IN the same Triangle A B C, let there be given (as before) the Base A B 405 Foot, and the Angle A B C 32 deg. and let it be required to find the Hypothenusa B C. Now because the Angle C B A is given, the other Angle B C A is also given; and the Proportion is,

As the Sine of the Angle B C A 58 deg.	9,928420
To the Logarithm of the Side 405 Foot	2,607455
So is the Sine of the Angle C A B 90 deg.	10,000000
The Sum of the second and third Number, added	12,607455
To the Logarithm of the Side B C	2,679035

The Number answering to this Logarithm is 477; and so many Feet is the Hypothenusa.

By the Line of Numbers and Sines.

Extend the Compasses from the Sine of 58 deg. to 405 in the Line of Numbers; the same extent will reach from the Sine of 90 deg. to 477 in the Line of Numbers; and that is the Length of the Side B C. Or you may extend the Compasses from the Sine of 58 deg. to 90 deg. the same extent will reach from 405 to 477, as before.

CASE III. *The Hypothenusa and Angle at the Base being given, to find the Perpendicular.*

IN the same Triangle let there be given the Hypothenusal B C 478 Feet, Poles, Miles, or Leagues, and the Angle at the Base C B A 32 deg. to find the Perpendicular C A.

The Proportion is,

As the Sine of the Angle C A B 90 deg.	10,000000
Is to the Logarithm of the Side B C 478	2,679428
So is the Sine of the Angle C B A 32 deg.	9,724210
To the Logarithm of the Side A C 253	12,403638

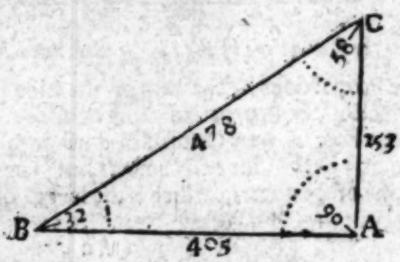
The Number answering to this Logarithm is 253, and that is the Length of the Side C A in Feet, Poles, Miles, or Leagues. Here the Work is something abreviated; for the Angle C A B being a Right Angle, and being the first Term when the second and third Terms are added together, the first is easily subtracted from it, by cancelling the Figure next your left hand, as you see in the Example; and so the rest is the Logarithm of the Number sought.

By the Line of Sines and Numbers.

Extend the Compasses from the Sine of 90 degrees, to 478; the same Extent will reach from the Sine of 32 degrees, to 253. Or, extend the Compasses from the Sine of 90 degrees, to the Sine of 32 degrees; the same Extent will reach from 478 to 253, and that is the Side C A.

CASE IV. *The Hypothenusal and Angle at the Base being given, To find the Base.*

LEt there be given in the Triangle the Hypothenusal B C, and the Angle at the Base C B A; and by consequence the Angle B C A the Complement of the other to 90 degrees: then to find B A, the Proportion is,



As the Sine of 90 deg. C A B ——— 10,000000
To the Hypothenusal C B 478 ——— 2,679428
So is the Sine of the Angle A C B 58 ——— 9,928420
To the Logarithm of the Base A B ——— 12,607848

The nearest Number answering to 2, 607848 is 405: and so many Foot or Poles, Miles or Leagues is the Base A B.

In the Art of Navigation, we may call one of the Sides, as A. B. the Long. or Meridian Distance; the other the Difference of Lat. as C. A; and the Hypothenusal, the Distance, as C. B.

By the Line of Sines and Numbers.

The Angle given, as before, extend the Compasses from the Sine of 90 deg. unto 478, the same Extent will reach from the Sine of 58 deg. to 405 in the Line of Numbers.

Or, Extend the Compasses from the Sine of 90 deg. to the Sine of 58 deg. the same Extent will reach from 478 to 405, which is the Length of the Base A. B.

CASE V. *Let the Perpendicular be the difference of Latitude* 253 *Leagues, and the Angle at* C, S. W. *by* W. 1 *deg.* 45 *min. Westerly, or* 58 *deg. Let it be given to find the Hypothenusal or distance upon the Rhomb.*

If the Perpendicular or Difference of Latitude 253 Leagues A C be given, and the Angle at A C B. S. W. by W. 1 deg. 45 min. Westerly, or 58 deg. Then by consequence the Angle A B C, or Complement of the Romb is also given; taking it out of 90 deg. then the *Hypothensual* may by found thus.

As the Sine Complement of the Rhomb 32 deg. the Angle at B, ——— 9,724210
Is to the Logarithm of the Difference of Latitude 253 ——— 12,403121
So is the Sine of the Angle or Radius 90 deg. ——— 10,000000

To the Logarithm of the *Hypothenusal*, or Distance sailed, 477 ——— 2,678911

Here because the Angle C A B is a Right Angle, or 90 deg. the Radius, and comes in the third place, I therefore only put an Unite before the Term, and so subtract the first Term, and the remainder is 2,678911; the absolute Number answering thereunto is 478, the Side required.

By the Line of Numbers.

Extend the Compasses from the Sine of 32 deg. to 253 deg. the same distance will reach from the Sine of 90 deg. to 477 the Side required.

Or, the distance between the Sine of 32 deg. and 90 deg. will be equal to the distance between 253 and 477, and giveth the Side required.

CASE VI. *The Hypothenusal or distance Sailed, and the Perpendicular or difference of Latitude given, To find the Rhomb or Angle* A B C.

In the foregoing Triangle, there is given the Hypothenusal or distance sailed, C B 478 Leagues, and the Perpendicular 253 Leagues, the difference of Latitude, and it is required to find the Angle A B C, the Rhomb between the South and the West.

As the Logarithm of the Hypothenusal C B 478 Leagues ——— 2,679428

Is to the Right Angle or Radius 90 deg. C A B ——— 10,000000
So is the Logarithm of the Perpendicular 253 C A ——— 2,403121

To the Compl. Sine of the Rhomb, or Sine of the Ang. A B C 31 d. 57 m. 9,723693

The nearest Logarithm answering to 9,723693, is the Sine of 31 deg. 57 min. which deducted from 90 deg. there remains the Angle of the Rhomb 58 deg. 3 min. or S. W. by W. 1 deg. 48 min. Westerly.

By the Line of Numbers.

Extend the Compasses from 478, to the Sine of 90; the same distance will reach from 253, to the 32 deg. *fere.*

Or,

Or, Extend the Compasses from 478 to 253; the same Extent will reach from the Sine of 90 to the Sine of 32 deg. *fere*, which is the required Angle A B C; and the Complement of the Rhomb.

CASE VII. *The Hypothenusal, and the Parallel of Longitude given, To find the Rhomb or Course Sailed.*

IN the foregoing Triangle there is given the Hypothenusal or distance sailed, C B 478 Leagues, and the Parallel of Longitude or Base 405 Leagues, to find the Course or Rhomb sailed, or the Angle A C B.

As the Hypothenusal or distance sailed 478 C B	2,679421
To the Right Angle C A B Radius or Sine of 90 deg	10,000000
So is the Parallel of Longitude, or Base A B 405 Leagues	12,607455
To the Sine of the Angle of the Rhomb or Course sailed 57 deg. 55. min. or S. W. by W. 1 deg. 40 min. Westerly.	9,9280

By the Lines of Sines and Numbers.

EXtend the Compasses from 478 in the Line of Numbers, to the Sine of 90 deg. the same Extent will reach from 405, to the Sine of 58 deg. *fere*.

Or, Extend the Compasses from 478 to 405; the same Extent will reach from the Sine of 90, to the Sine of 58 deg. *fere*, A C B, the Angle of the Rhomb or Course sailed, which was required.

CHAP IV. *Of Oblique-Angled Plain Triangles.*

CASE I. *Having two Angles, and a Side oppofite to one of them, To find the Side opposite to the other.*

IN the Triangle Q R S, is given the Angle Q S R, 25 d. 30 m. and the Angle Q R S 45 d. 20 m. and the Side Q S, 305 Feet; And it is required to find the Side Q R.

Here note, that in Oblique-Angled Plain Triangles, as well as in Right Angled, the Sides are in proportion one to the other, as the Sines of the Angles apposite to those Sides. Therefore,

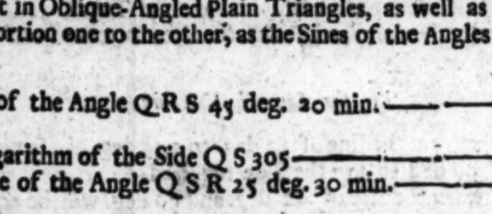
As the Sine of the Angle Q R S 45 deg. 20 min.	9,851977
Is to the Logarithm of the Side Q S 305	2,484299
So is the Sine of the Angle Q S R 25 deg. 30 min.	9,633984
The Sum of the second and third Terms	12,118283
The first Term subtracted	9,851977
To the Logarithm of the Side Q R	2,266306

The nearest Number answering to this Log. is 184; and so many Feet is the Side Q R.

By the Line of Sines and Numbers.

THe Line of Sines and Numbers will resolve the Triangle by the same manner of Work, as in the other before. For if you extend the Compasses from the Sine of 45 deg. 20 min. to 305 Foot, the same distance will reach from 25 deg 30 min. to 184 Foot, and so much is the Side Q R.

Or, Extend the Compasses from the Sine of 45 deg. 20 min. to 25 deg. 30 min. the same distance will reach from 305 to 184, the length of the Side inquired.



In like manner if the Angle R Q S, 109 deg. 10 min. and the Angle Q R S 45 deg. 20 min. and the Side Q S 305 Foot, had been given, and the Side R S required, the manner of Work had been the same: For,

As the Sine of the Angle Q R S 45 deg. 20 min.	9,851997
Is to the Logarithm of the Side Q S 305	2,484299
So is the Sine of R Q S 109 deg. 10 min. (or 70 deg. 50 min.)	9,975233
The Sum of the second and third Terms	12,459532
The first Term subtracted	9851997
To the Logarithm of the Side R S 405	2,607535

The Absolute Number answering to this Logarithm is 405, and so much is the Side R S.

In this Case, because the Angle R Q S is more than 90 deg. you must therefore take the Complement thereof to 180 deg. so 109 deg. 10 min. being taken from 180 deg. there remains 70 deg. 50 min. whose Sine is the same with 109 deg. 10 min. And so you must work with all Angles above 90 deg.

By the Line of Numbers and Sines.

Extend the Compasses from the Sine of 45 deg. 20 min. to 305 Feet, the same distance will reach from 70 deg. 50 min. to 405.

Or the Compasses extended from the Sine of 45 deg. 20 min. to 70 deg. 50 min. the same Extent will reach from 305, to 405 in the Line of Numbers, which is the Side R S required.

CASE II. *Two Sides and an Angle opposite to one of them being given, To find the Angle opposite to the other.*

In the same Triangle let there be given the Side Q S 305, and Q R 185 Feet, together with the Angle Q S R 25 deg. 30 min. 30 min. and let it be required to find the Acute Angle Q R S. The Proportion is,

As the Logarithm of the Side Q R 185	2,267172
Is to the Side of the Angle Q S R 25 deg. 30 min.	9.633984
So is the Logarithm of the Side Q S 305	2,484299
The Sum of the second and third Numbers	12,118283
The first Number subtracted from the Sum	2,267172
To the Sine of the Angle Q R S 45 deg. 13 min.	9,851111

The nearest deg. answering to this Sine is 45 deg. 13 min. which is the Angle required Q R S, if the Angle required had been Obtuse, it would have been 134 deg. 47 min.

By the Line of Sines and Numbers.

Extend the Compasses from 185, to 25 deg. 30 min. the same distance will reach from 305, to 45 deg. 13 min. the Angle Q R S.

Or extend the Compasses from 185, to 305; the same extent will reach from 25 deg. 39 min. to 45 deg. 13 min. as before.

CASE III. *Having two Sides, and the Angle contained between them given, To find either of the other Angles.*

In the same Triangle, suppose there were given the Side R S 406, and the Side R Q 185, and the Angle comprehended by them, namely the Angle a R, 45 deg. 20 min. and it were required to find either of the other Angles.

First, Take the Sum and Difference of the two Sides given; there Sum is 591, and their difference is 221. Then knowing that the three Angles of all Right-lin'd Triangles, are equal to two Right Angles, or 180 deg. (by the 17th Theor. of Chap. 3.) Therefore

fore the Angle S Q R being 45 deg. 20 min. if you subtract this Angle from 180 deg. the remainder will be 134 deg. 40 min. which is the Sum of the two unknown Angles at Q and S; the half thereof is 67 deg. 20 min.

The Side R S—406 Paces.
The Side R Q—185 Paces.

The Sum———591 } of the Sides given,
The Difference—221 } R S and R Q.

	deg.	min.
Two Right Angles	180	00
The Angle at R	045	20
The Sum of the two opposite Ang.	134	40
The half Sum	067	20

The Sum and Difference of the Sides being thus found, and also the Half-Sum of the two unknown Angles, the Proportion by which you must find the Angles severally is,

As the Logarithm of the Sum of the Sides 591———2,771587

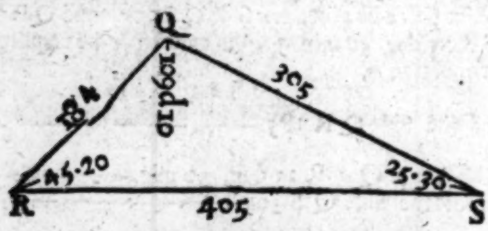
Is to the Logarithm of the difference of the Sides 221———2,344392
So is the Tangent of the half Sum of the two unknown Angles 67 deg. 20 min.———10,379213

The Sum of the second and third Number———12,723605 | $\frac{1}{2}$ Sum 67 20
Tang. 41 50

The first Number subtracted from the Sum———2,771587 | 109 10

The Tangent of 41 deg. 50 min.———9,952018 | Lesser Angle } 25 30

Which added to the Half Sum, makes The greater of the Angles required, } 109 deg. 10 min. Greater Angle.
Subtract 41 deg. 50 min. from the Half Sum, leaves the lesser Ang. at S. } 25 deg. 30 min. Lesser Angle



By the Line of Tangents and Numbers.

Extend the Compasses from the Sum of the Sides 591, to the difference of the Sides 221; the same Extent upon the Line of Tangents will reach from 67 deg. 20 min. the Half Sum, to the Tangent of 41 deg. 50 min.

CASE IV. *Two Sides and their Containing Angle given, to find the third Side.*

There is given R S 406 Paces and R Q 185 Paces, and the Angle at R 45 deg. 20 min. By the 10th Case, to find the Side Q S.

As the Sum of the Sides given R S and R Q 591 Paces———2,771587

Is in proportion to their Difference R S and R Q 221———2,344392
So is the Tangent of the Half Sum of the two opposite Angles Q and S unknown } 67 degrees 20 Minutes: 10,379213
12,723605

To the Tangent of———41 degrees 50 minutes—9,952018
Which added to the half Sum———67 20

gives the greater Angle at Q required——109 10

Then

Then say, As the Sine of the Angle found 109, or 70 deg. 50 min——9,975233

Is in proportion to his opposite Side R S 406 Paces——2,608526
So is the Sine of the Angle given at R 45 deg. 20 min.——9,851997

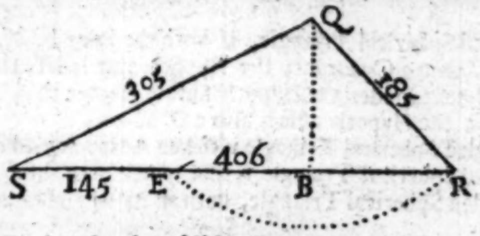
To his opposite Side required, Q S 306 Paces *fere*——12,460523
The Logarithm of the Side required——2,485290

By the Line of Sines and Numbers, to find the third Side.

Extend the Compasses from the Sine of 70 deg, 50 min. to R S 406 Paces; the same extent will reach from the Sine of 45 deg. 20 min. to the Side 305.

Or, Extend the Compasses from the Sine of 70 deg. 50 min. to the Sine of 45 deg. 20 min. the same Distance will reach from 406, to 305 Paces, which is the Length of the Side Q S, which is required.

CASE V. *Three Sides of an Oblique Triangle being given, to find the Angles.*



IN this Triangle S Q R, let the three Sides known,

The Side S R——406
The Side S Q——305
The Side Q R——185

And it is required to find the three Angles.

To perform this, you must first let fall a Perpendicular from the Point Q, upon the Side R S, which you may do by setting one foot of your Compasses in the Point Q, and open the other to the Point R, draw the Arch R E, and divide the space E R, into two equal parts; and so the Perpendicular will fall upon the Point B.

To perform this by Numbers.

As the greater Side or Base S R, 406——2,608526

To the Sum of the two lesser Sides 490——2,690196
So is the Difference of these two Sides 120——2,079181

To the Part S E (cut off by the Arch R B E) 145——4,769377
2,608526

2,160851

This subtracted from the whole Line 406, leaves for the part within the Arch 261; the half thereof is $130\frac{1}{2}$, which is the Place B where the Perpendicular will fall, reckoned from the Angle R; and by this Perpendicular you have divided the Triangle into two Right Angles, whose Sides are known: For R B being $130\frac{1}{2}$, subtracted from the whole Line S R 406, leaves for the remaining Part $275\frac{1}{2}$. Now having those two Sides of the two Right-angled Triangles, and the two first given Sides, 305 and 185, being the two Hypothenusals thereof, you may by the opposition of sides to their Angles, (as in the 7 Case of Right-angled Triangles) find the required Angles.

By the Line of Sines and Numbers;

Extend the Compasses from 406 to 490; the same Distance will reach from 120, to 145 S E Leagues, the Side required.

CHAP. V. *Of the Affection of Spherical-Triangles,*

A Spherical Triangle is described on the surface of the Sphere.

The Sides of a Spherical Triangle, are the Arches of three great Circles of the Sphere, mutually intersecting each other.

A

A great Circle divides the Superficies of the Sphere into two equal parts.

The Angles of a Spherical Triangle, are measured by an Arch of a great Circle inter-secting the containing Sides at Right Angles, whose Pole is the Angular Point.

The Sum of the three Sides of a Spherical Triangle are less then two Semicircles.

The Sum of the three Angles of a Spherical Triangle, are greater than two Right An-gles and less than six.

Spherical Triangles are either Right-angled or Oblique-angled.

A Right-angled Spherical Triangle, is that which hath one Right-angle at the least.

An Oblique-angled Spherical Triangle, is that which hath never a Right-Angle.

In a Right-angled Spherical Triangle, the two Sides containing the Right Angle are called Leggs, and the Side opposite to the Right Angle the Hypothenuse.

In a Right-Angled Spherical Triangle, the Oblique Angles are of the same kind with their opposite Legs: that is, if either of the Legs be a Quadrant, the opposite Angle is a Right Angle; if either of the Legs be less than a Quadrant, the opposite Angle is Acute; and if either of the Legs be greater than a Quadrant, the opposite Angle is Obtuse.

In a Right-angled Spherical Triangle, if both the Legs be of one kind, that is both greater or both less than a Quadrant, the Hypothenuse is less than a Quadrant; but if the Legs be of different kinds, the Hypothenuse is greater than a Quadrant, and if the Legs be Quadrants, the Hypothenuse is also a Quadrant.

An Oblique-angled Spherical Triangle is either Acute-angled or Obtuse-angled.

An Acute-angled Spherical Triangle, is that which hath three Acute Angles.

An Obtuse-angled Spherical Triangle, hath all its Angles either Obtuse or mixt, as Acute and Obtuse.

The three Sides of an Acute-angled Triangle, are each of them less than Quadrants.

In Spherical Triangles there are 28 Cases, 16 in Right-angled Triangles, and 12 in Oblique-angled Triangles.

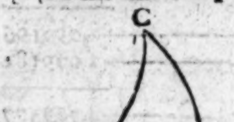
CHAP. VI. *Containing the Doctrine of Right-angled Spherical Triangles.*

CASE I. *The Legs given, to find the Hypothenuse.*

The Proportion.

As Radius,
To the Sine Compl. of one of the Legs,
So is the Sine Compl. of the other Leg,
To the Sine Compl. of the Hypothenuse required.

Example.



In the Triangle A B C, there is given;

	deg.	min.	
A B	60	07	A C required:
B C	51	32	

The Operation.

As Radius		10,0000
To Sine Compl. A B 60 deg. 07 min.		9,6974
So is Sine Compl. BC 51	32	9,7938
To Sine Comp. A C 71	57	19,4911

CASE II. *The Legs given, to find one of the Oblique Angles.*

The Proportion.

As Radius,
To the Sine of the adjacent Leg;
So is the Tangent of the opposite Leg:
To the Tangent Compl. of the Angle required.

CASE III. *One of the Legs and an adjacent Angle being given, to find the opposite Leg.*

The Proportion.

As Radius,
To the Sine of the adjacent Leg:
So is the Tangent of the adjacent Angle:
To the Tangent of the Leg sought.

CASE IV. *One of the Legs and an adjacent Angle being given, to find the Hypothenuse.*

The Proportion.

As Radius,
To the Sine Compl. of the adjacent Angle;
So is the Tangent Compl. of the adjacent Leg;
To the Tangent Compl. of the Hypothenuse required.

CASE V. *One of the Legs and the adjacent Angles being given, to find the opposite Angle.*

The Proportion.

As Radius,
To the Sine Compl. of the adjacent Angle;
So is the Sine Compl. of the adjacent Side;
To the Sine Compl. of the Angle required.

CASE VI. *The Hypothenuse and one of the Oblique Angles being given, to find the adjacent Leg.*

The Proportion.

As Radius,
To the Sine Compl. of the given Angle;
So is Tangent of the Hypothenuse;
To the Tangent of the Leg required.

CASE VII. *The Hypothenuse and one of the Oblique Angles being given, to find the Leg opposite to the given Angle.*

The Proportion.

As Radius,
To the Sine of the Hypothenuse,
So is the Sine of the given Angle;
To the Sine of the Leg sought.

CASE VIII. *The Hypothenuse and one of the Oblique Angles being given, to find the other Oblique Angle.*

The Proportion.

As Radius,
To the Sine Compl. of the Hypothenuse;
So is the Tangent of the given Angle;
To the Tangent Compl. of the Angle sought.

CASE IX. *The Hypothenuse and one of the Legs given, to find the other Leg.*

The Proportion.

As Radius,
To the Sine of the given Leg;
So is the Sine Compl. of the Hypothenuse;
To the Sine Compl. of the Leg required.

CASE X. *The Hypothenuse and one of the Legs given, to find the Angle adjacent to the given Leg.*

The Proportion.

As Radius,
To the Tangent Compl. of the Hypothenuse;
So is the Tangent of the given Leg;
To the Sine Compl. of the Angle required.

CASE XI. *The Hypothenuse and one of the Legs given, to find the Angle opposite to the given Leg.*

The Proportion.

As Radius,
To the Sine Compl. of the Hypothenuse;
So is the Sine of the given Leg:
To the Sine of the *Angle* required.

CASE XII. *One of the Oblique Angles and the opposite Leg being given, to find the other Leg; it being known whether the Leg required be greater or less than a Quadrant.*

The Proportion.

As Radius,
To the Tangent Compl. of the given *Angle*;
So is the Tangent of the given Leg;
To the Sine of the Leg sought.

CASE XIII. *One of the* Oblique Angles *and the opposite Leg being given, to find the Hypothenuse; it being known whether the Hypothenuse be greater or less than a Quadrant.*

The Proportion.

As Radius,
To the Sine Compl. of the given *Angle*;
So is the Sine of the given Leg;
To the Sine of the Hypothenuse required.

CASE XIV. *One of the Oblique Angles and the opposite Leg being given, to find the other Angle; it being known whether the Angle sought be Acute or Obtuse.*

The Proportion.

As Radius,
To the Sine of the given Leg;
So is the Sine Compl. of the given *Angle*;
To the Sine of the *Angle required.*

CASE XV. *The two Oblique Angles being given, to find the Hypothenuse.*

The Proportion.

As Radius,
To the Tangent Compl. of one of the given *Angles*;
So is the Tangent Compl. of the other given *Angle*;
To the Sine Compl. of the Hypothenuse required.

CASE XVI. *The two Oblique Angles being given, to find one of the Legs.*

The Proportion.

As Radius,
To the Sine Compl. of one of the given *Angles*:
So is Sine Compl. of the other given *Angle*:
To the Sine Compl. of the Leg sought.

CHAP. VI. *Containing the Doctrine of Oblique-angled Spherical Triangles.*

I. CASE. *Two sides and an Angle opposite to one of them being given, to find the other opposite Angle; if it be known whether the required Angle be Acute or Obtuse.*

The Proportion.

As the Sine of the given Side,
To the Sine of the given *Angle* opposite thereto;
So is the Sine of the other given Side;
To the Sine of the opposite *Angle* required.

Example. In the Triangle A D E there is given

AED 29 55
AD 34 59 } D A E required being acute.
DE 60 10

The

The Operation.

	deg.	min.	
As the Sine A D	34	59	9,758411
To Sine A E D	29	55	9,697874
So is Sine D E	60	10	9,938257
			19,636131
To Sine D A E	48	59	9,877720

II. CASE. *Two Angles and a Side opposite to one of them being given, To find the other opposite Side, if it be known, whether it be greater or less than a Quadrant.*

The Proportion.

As the Sine of a given Angle,
To the Sine of the Side opposite thereto;
So is the Sine of the other given Angle;
To the Sine of the opposite Side required.

III. CASE. *Two Sides and their contained Angle being given, to find the opposite Angles.*

The Proportion.

As the Sine of half the Sum of the two given sides,
To the Sine of half their Difference;
So is the Tangent Complement of half the contained Angle;
To the Tangent of half the Difference of the opposite Angles. And

As the Sine Compl. of half the Sum of the two given sides,
To the Sine Complement of half their Difference;
So is the Tangent Compl. of half the contained Angle,
To the Tangent of half the Sum of the opposite Angles.

Then to the half Sum of the opposite Angles, add their half difference, the Sum is the greater of the two *Angles* sought: And from the half sum of the opposite *Angles* subtract their half difference, the remainder is the lesser of the opposite *Angles* required.

IV. CASE. *Two Angles and the Side between them being given, To find the opposite Sides.*

The Proportion.

As the *Sine* of half the sum of the two given *Angles*,
To the *Sine* of half their Difference;
So is the Tangent of half the *Side* between them;
To the Tangent of half the Difference of the opposite *Sides*. And

As the *Sine Compl.* of the half sum of the two given *Angles*,
To the *Sine Compl.* of half their Difference;
So is the Tangent of half the *Side* between them;
To the Tangent of half the sum of the opposite *Sides*.

Note, That in the third and fourth Cases before-going, if the Sum of the two given Sides, or two given Angles exceed 180 deg. then take the Complement of those Sides or Angles to 180 deg. severally, instead of the *Sides* or *Angles* given; and the *Angles* or *Sides* produced by the Operation, are the Compl. of the *Angles* or *Sides* sought to 180 deg.

V. CASE. *Two Sides and an Angle opposite to one of them being given, To find the third Side; if it be known whether the Angle opposite to the other given Side be Acute or Obtuse.*

The Proportion.

First find the *Angle* opposite to the other given *Side*, by the first Case of Oblique-angled Triangles; Then say,

As

As the *Sine* of the Difference of half the opposite *Angles*,
To the *Sine* of half the sum of those *Angles*;
So is the Tangent of half the Difference of the two given *Sides*;
To the Tangent of half the *Side* required.

VI. CASE. *Two Angles and a Side opposite to one of them being given, To find the third Angle, if it be known whether the Side opposite to the other given Angle be greater or less than a Quadrant.*

The Proportion.

First find the *Side* opposite to the other given *Angle*, by the second Case of Oblique-angled Triangles; Then say.

As the *Sine* of half the Difference of the opposite *Sides*,
To the *Sine* of half the sum of those *Sides*.
So is the Tangent of half the Difference of the two given *Angles*:
To the Tangent Complement of half the *Angle* sought.

VII. CASE. *Two Sides and an Angle opposite to one of them being given, To find the contained Angle; if it be known whether the Angle opposite to the other given Side be Acute or Obtuse.*

The Proportion.

First, find an Angle opposite to the other given *Side*, by the first Case; Then say,

As the *Sine* of half the Difference of the two given *Sides*;
To the *Sine* of half the sum of those *Sides*.
So is the Tangent of half the Difference of the opposite *Angles*
To the Tangent Complement of half the *Angle* required.

VIII. CASE. *Two Angles and a Side opposite to one of them being given, To find the Interjacent Side; if it be known whether the Side opposite to the other given Angle, be greater or less than a Quadrant.*

First find the *Side* opposite to the other given *Angle*, by the 2d Case; Then say,

As the *Sine* of half the Difference of the two given *Angles*,
To the *Sine* of half the sum of those *Angles*;
So is the Tangent of half the Difference of the opposite *Sides*;
To the Tangent of half the *Side* required.

IX. CASE. *Two Sides and the contained Angle being given, To find the third Side.*

The Proportion.

As Radius,
To the *Sine Complement* of the contained *Angle*;
So is the *Tangent* of the lesser *Side*,
To the *Tangent* of an *Arch*.

If the given *Angle* be *Acute*, subtract this Arch from the greater of the two given *Sides*; but if the given *Angle* be Obtuse, subtract it from the Complement thereof to 180 deg. and note the remainder. Then say,

As the *Sine Complement* of the Arch found,
To the *Sine Complement* of the Remainder;
So is the *Sine Complement* of the lesser of the contained *Sides*.
To the *Sine Complement* of the *Side* required.

X. CASE. *Two Angles and the interjacent Side being given, To find the third Angle.*

The Proportion.

As Radius,
To the Sine Complement of the interjacent Sides,
So is the Tangent of the lesser of the two given Angles;
To the Tangent of an Arch.

If

If the interjacent *Side* be greater than a Quadrant, subtract the Arch found from the greater of the given Angles, but if it be less than a Quadrant, subtract it from the Complement of the said Angle to 180 deg. and note the Remainder. Then say,

As the *Sine Complement* of the Arch found,
To the *Sine Complement* of the Remainder ;
So is the *Sine Complement* of the lesser Angle,
To the *Sine Complement* of the Angle required.

XI CASE. *Three Sides given, To find an Angle.*

To perform this Case by the Logarithms, take the following Direction.

First set down the two Sides containing the required Angle, and then the Side opposite thereto ; add the three Sides together, and take the half sum thereof from the half sum of the three Sides ; subtract the Side opposite to the Angle required, and subscribe the Remainder. Then to the Complement Arithmetical of the Sines of the containing Sides add the Sines of the half sum and remainder, half the Sum of these four Logarithms, is the Sine Complement of half the Angle required.

XII CASE. *Three Angles being given, To find a Side.*

To perform this Case, take the Complement of the greatest Angle to 180 deg. which use instead of that Angle, then set down the two Angles adjacent to the required Side, and then the Angle opposite thereto ; add these three Angles into one sum, and take the half thereof, from this half Sum subtract the Angle opposite to the required Side, and subscribe the remainder. Then to the Complement Arithmetical of the Sines of the two adjacent Angles, add the Sines of the half sum and remainder ; half the sum of these four Logarithms, is the Sine Complement of half the Side required.

Only Note, That if the greatest Side of the Triangle be required ; This Operation produces the Complement thereof to 180 deg.

The End of the Third Book.

The Fourth Book.

CHAP. I.

Of Sailing by the Plain Chart, and the Uncertainties thereof.

THE *Art of Navigation*, is a Science directed by many Rules to Steer a Ship through the Sea, from the one place to the other ; and may not improperly be divided into two Parts ; namely, the *Common*, and the *Artificial Navigation*.

The *Common Navigation* requireth the Use of no Instruments but the Compass and Sounding-Lead, as chiefly consisting in Practice and Experience in the knowledge of Lands and Points, how they lie, and their Distance one from the other, in knowledge of Depths and Shoals, and Varieties of Grounds, the Course and Setting of Tides ; upon what Point of the Compass the Moon maketh High-Water in each several place, and the like ; which must be known partly by the Information of Skilful Pilots, and Instructions in Books for that purpose, but far better by a Man's own Experience.

The *Artificial Navigation* useth, besides the foresaid Common Practice, divers other Instruments and Rules, which they take from Astronomy and Cosmography. It is therefore needful that those who take charge of any Ship or Vessel in this part of Navigation, be first and chiefly well instructed in the principal Points of the aforesaid Arts ; that is, know the Order and understand the Division of the Sphere of the World, and the motions of the Heavens ; together with the contriving or making and use of Instru-

ments, as I have shewn briefly in the Second Book. For without this Knowledge it is impossible to perform great Voyages by the Sea. In regard this Knowledge may be attained to, by good Instruction, we have set forth the same in this Treatise, for the benefit of such young Sea-men, as are desirous to be Sea-Artists or Navigators, as clearly and plainly as the brevity of the same could permit.

The Defects and Imperfections of this Art are many; partly in the Skill or Theorick, partly in the Practick.

After a long Voyage, the Ship supposed to be near the Shore, the Commander or Master requires from his Mates an account of their Judgment how the Land or Cape bears from them, and the Distance from it. He that comes nearest the Truth is supposed to have kept the best Reckoning. I have known some, that have scarce been able to number five Figures, have gone nearer the Truth than the best Artist in the Ship; but they have been wonderfully mistaken (to my Knowledge) in other Voyages.

I went a Voyage to *Barbadoes*, in the Rainbow, and took our Reckoning from *Lunday*, in the Mouth of *Severn*; and in the Ship were twelve Practitioners that kept an account; eleven of them kept it by the Plain Chart, and my self made use of *Mercator* or *Wright*'s Projection. When we came in the Latitude (which was 400 Leagues from the Island) every Man was ready to give his Judgment of his Distance off the *Barbadoes*. But they all fell wonderfully short of the Truth; for he that should have had the best Reckoning, was 300 Leagues short, and most of all the rest was 268 and 250 Leagues; and he that was accounted an excellent Artist aboard the Ship was 240. But by the Reckoning kept by *Mercator*'s Chart, there wanted but three Leagues short of the true Distance of the Island.

In the same Ship, going from thence to *Virginia*, they also fell short, by the same way of Account by the Plain Chart 90 Leagues the nearest; and those that were advised to keep it by *Mercator*, found it to come but 4 or 5 Leagues short of the Cape of *Virginia*. But coming from thence home, they got their Credit again, coming all within 30 Leagues of the true Distance from the Shore.

But we find that there is near 180 Leagues difference Error, between the Meridian of *Barbadoes*, and *Lunday*, and much more in the Distance; and in some Charts about 620 Leagues Error, in the Distance between *Cape Fortuna*, the South Cape of *Anian*. These Errors may be ascribed partly to the uncertainty of the Longitude, and partly unto the Plain Chart, and Sailing by it, which makes some Places nearer than they are, and other Places far more distant than they are, and scituated much out of their true Course or Rhomb.

Secondly, Men many times commit great Errors in bad Steerage, and careless looking to the Compass; for I have known many Sea-men when their Trike at Helm hath been out, and the Log hove, they have told the Master or his Mate, they have steer'd half a Point a Weather the Course; besides, the Points of the Needle or Wyers being touched by the Load-stone, are subject to be drawn aside by the Guns in the Steerage, or any Iron near it, and liable to Variation, and do not shew the true North and South, which ought continually to be observed by a good Azimuth Compass, (such a one you have described, by which I survey Land in the following Treatise:) so the Variation ought to be carefully allowed.

I found 11 deg. in a Field at St. George's, and Bristol being fair Miles dist. and I made five Observations, and differ. ½ of a deg. only.

Besides, on Land there is a difference in the same Place, as *Gunter* in his Observations at *Limehouse*, for the finding the Variation, found it half a Degree more, and in other Places of the same Ground less; and *Matius* saith, he hath found a Degree or two difference. This difference at Land must needs shew the uncertainty we have at Sea. Besides, many times the Ship is carried away by unknown Currents, which when they be discovered by their Ripplings, as also some by reason of Trade-Winds, we set them in our Journal.

Currents are a means of great mistakes in keeping of a Reckoning; for Capt. *Fox* in his North-West Discoveries, and the rest complained much of the fast Lands of Ice upon those Coasts, that so alters the Current, that in some places they cannot make good their Course they steer upon by three Points; especially in *Davis Streights*, where steering E. by S. they scarce could make good S. E. by S. which is four Points of the Compass.

I have also perceived a good Current to set to the E. S. E. about the Western Islands, and the *Madeira's*, in several Voyages I have made to the *West-Indies*; but more especially I have observed it in my last Voyage to *Barbadoes*. I went out of *England* in Company with Capt. *Blackman*, in the Eagle bound to the *East-Indies*, and a Dutch Ship in his

Com-

Company, and one of *Plymouth* for the *Isle* of *May*: we kept Company together as far as the *Madera's* but intended not to see it that Voyage; for we reckoned our selves 25 Leagues, and some more to the Westward of the Meridian of the *Madera's*: But being in the Latitude near it, we espied the Land; and being becalm'd, drove with the Current by the Eastern end of the Island, betwixt *Porto Sancto*, and the Desarts or Rocks that ly off from that end. I compared Reckoning with most aboard each Ship that kept account, and found some 30 Leagues to the Westward of the Island; and thereby and in five Voyages made before that way, knew by experience there is a Current sets strongly near the Island E. S. E. Besides several Ships of *London* and the *West-Country* have mist it. *Snellius* instanceth, That one of good repute, sailing out of *Holland*, mist it twice.

How we keep our Reckoning. The first and most useful Question in Navigation, is this; By the knowledge of the Rhomb or Course you sailed upon, and the Distance of Miles or Leagues that you sailed thereon, to know your difference of Latitude and Longitude (that is, how much you are Northerly or Southerly in respect of Latitude, or Easterly or Westerly in respect of Longitude.) This is the most ordinary manner of keeping of Account by most Masters and Mates, of the Ships Way; which is called the Dead Reckoning.

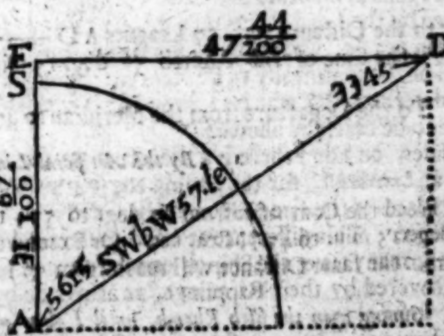
And to keep this account, first you see, That the knowledge of the Rhomb they sailed, is always supposed to be had off the Log-Board, supposing the Compass by which we steer, either doth, or should shew the same exactly; and so you have the Distance in Miles and Leagues, put down every half Watch upon the Log-Boards. Therefore we will first question, and resolve it by the Traverse-Table following, and also by the Traverse-Scale in the fifth Chapter of the second Book. (I have shew'd it by the Synical Quadrant already in the sixth Chapter of the second Book.) And we will resolve it also by the Artificial Sines and Tangents on the Ruler, and the Tables of Logarithms. But know this, never any steer'd at Sea, nearer than to half a Point; and that there are no Halfs nor Quarters marked on the Compass Chart.

The first Proposition. Questions of Sailing by the Plain Sea Chart.

I. *Sailing* 57 *Leagues upon the fifth Rhomb, How much shall I alter my Parallel of Latitude?*

THE Angle that any Point makes with the Meridian, we call the Rhomb; but the Angle that it makes with any Parallel, is called the Complement of the Rhomb. Unto every Point of the Compass there answers 11 deg. 15 min. therefore the 5th Rhomb from the Meridian makes Angles therewith of 56 deg. 15 min. namely, S. W. by W. S. E. by E. N. W. by W. N. E. by E. whose Complement, 33 deg. 45 min. is the Angle of the same Rhomb with every Parallel.

Admit I sail from A *to* D, *S. W. by W.* 57 *Leagues, I demand the difference of Latitude* E A;



First, by the following Traverse-Table, at the Head of the Table, over every Column, is put the Figure of the Halfs, Quarters, and the Points of the Compass, and in one of the Columns over head is N. S. and at the Foot E. W. and so is numbred at the Head, from the left hand to the right, N. S. stands for Northing. Then the Rhombs are reckoned at the bottom, from the right hand back again; the Margent of the Tables shew the Leagues sailed; and over E. W. or under E. W. shews how much you have sailed East or West from the Meridian N. S. shews North or South from the Latitude you came from.

As in this Example. The Distance sailed is 57 Leagues on the 5th Rhomb; therefore against Distance sailed, In the Side 57 Leagues, and in the Common Angle or Line of Meeting, I find 31. 67 over N. S. in the Foot; and in the next Column, over E. W. is 47.39, as you see in the Table: So that the Difference of Latitude is 31 Leagues and $\frac{67}{100}$ Parts of a League. And if it were required to find the Departure, you see it to be 47 Leagues and $\frac{39}{100}$ Parts. This is very plain and easy; you need no farther Precept.

By

By the Traverse-Scale.

Extend the Compasses in the Line of Numbers, from the end of the Line marked North South 57, the same Distance will reach from 5 Points to 31, and about $\frac{67}{100}$ in the Line of Numbers.

By the Artificial Sines and Numbers on the Ruler.

Extend the Compasses from Sine 90 deg. to 57 on the Line of Numbers; the same Distance will reach from the Sine Complement of the Rhomb, to the Difference of Latitude.

By the Tables of Artificial Sines and Numbers by the 4th Case of Plain Right-angled Triangles.

As the Radius, or the Sine of 90 deg.	10.00000
Is to the Distance run 57 Leagues A D	1.75587
So is the Sine Compl. of the Rhomb at the Angle D. 33 deg. 45 min.	9.74473
To the Difference of Latitude required A E 31 Leagues $\frac{67}{100}$	1.50061

In like manner you may find the Diff. of Lat. for any Distance run upon any Point of the Compass.

II. *Sailing 57 Leagues upon the first Rhomb, How far am I departed from the Meridian of the Place from whence I came?*

By the Traverse-Table.

This Question was answered in the last Example, and found over E. W. to be 47 Leagues and $\frac{47}{100}$. In like manner you may find the Diff. of Lat. and Departure from the Meridian, for any Distance run upon any Point of the Compass, which is the use of that Table.

By the Traverse Scale.

Extend the Compasses from the end of the Line marked East, West, to the Distance run 57 Leagues, then put one Point of the Compass on 5 Points, in the Line of East and West of the Scale, and the other will reach to the Departure from the Meridian 45 Leagues Parts.

By the Tables of Sines and Numbers, by the third Case of Plain Right-angled Triangles.

As the Radius or Sine of 90 deg.	10.00000
Is to the Distance run, 57 Leagues A D	1.75587
So is the Sine of the Rhomb 56 deg. 15 min. the Angle at A	9.91984
To the Departure from the Meridian to 47 $\frac{47}{100}$ E D	1.67572

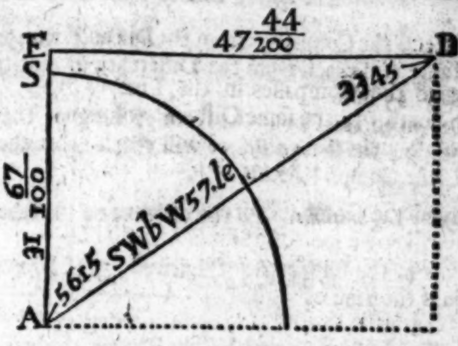
By the Artificial Lines on the Ruler.

Extend the Compasses from 90 deg. to 57; the same Distance will reach from the Sine 56 deg. 15 min. to 47 $\frac{47}{100}$ Leagues. Or Extend the Compasses from Sine 90, to Sine 56 deg. 15 min. the same Distance will reach from 57 Leagues, to 47 $\frac{47}{100}$, as before.

III. *Sailing upon the fifth Rhomb, until I alter my Latitude 31 $\frac{67}{100}$ Leagues. I demand how far I have sailed?*

As sailing from A to D, S. W. by W. till the Difference of Latitude be 31 Leagues $\frac{67}{100}$, I demand the distance run A D.

First, By the Traverse Table, look in the Foot of the Table for the 5th Rhomb, and over N. S. in that Column, look for 31 Leagues $\frac{67}{100}$, and in the Common Angle of Meeting, to the left hand, under Distance sailed, you will find Distance Sailed 57 Leagues required.



By the Line of Sines and Numbers.

Extend the Compasses from the Complement-Sine 33 deg. 45, to $31\frac{67}{100}$ the Difference of Latitude; the same extent will reach from Sine 90 deg. to 57 Leagues.

Or, Extend the Compasses from Sine 33 deg. 45 min. to Sine 90; the same Distance will reach from $31\frac{67}{100}$ Leagues, to 57 Leagues, the Distance A D, as before.

By the Logarithms. Say by the second Case in Plain Right-angled Triangles.

As the Sine Compl. of the Rhomb, 33 deg. 45	9.744739
Is to the Difference of Latitude $31\frac{67}{100}$ Leagues	1.500648
So is the Sine of 90 deg. or Radius	10.000000
To the Distance run A D 57 Leagues	1.755909

IV. *Sailing upon the fifth Rhomb, until I have altered my Latitude 31 $\frac{67}{100}$ or 1 deg. 35 min. How much am I departed from my first Meridian?*

As Sailing from A to D, S. W. by W. till the Difference of Latitude A E be $31\frac{67}{100}$ Leagues, I require B G my Departure from my Meridian.

By the Traverse Table.

As in the last Case, find $31\frac{67}{100}$ Leagues, over the fifth Rhomb, and in the next Column to the left hand, over E. W. is $47\frac{44}{100}$ Leagues the Departure required.

By the Line of Sines and Numbers.

Extend the Compasses from the Complement Sine of the Rhomb, to 33 deg. 45, to 31 $\frac{67}{100}$ the Leagues; the same Distance will reach from Sine 56 deg. 15 min. the Rhomb, to $47\frac{44}{100}$ Leagues, the Departure from the Meridian.

By the first Case of Plain Right-angled Triangles.

As Radius	10.000000
To the Difference of Latitude A E $31\frac{67}{100}$	1.500648
So is the Tangent of the Rhomb 56 deg. 15	10.175107
To the Departure from the Meridian $47\frac{44}{100}$ Leagues	1.675755

V. *Sailing upon some Rhomb between the South and the West 57 Leagues, and finding I have altered my Latitude $31\frac{67}{100}$ Leagues, I demand upon what Point I have Sailed?*

Admit I had sailed from A to D (being a Rhomb between the W. and S.) 57 Leagues, and then find the Difference of Latitude $31\frac{67}{100}$ Leagues, I demand the Angle DAE.

By the Traverse-Table.

Against 57 Leagues in the Column of Distance sailed, and in that Line or Common-Angle of Meeting, you must find the Difference of Latitude $31\frac{67}{100}$ Leagues, which will be over the fifth Rhomb, which was required.

By the Line of Sines and Numbers on the Scale.

Extend the Compasses from the Distance run 57 Leagues, to the Sine of 90; the same Distance will reach from the Difference of Latitude, to the Sine-Compl. of the Rhomb 33 deg. 45 min.

Or, open the Compasses from 57 Leagues the Distance, to $31\frac{67}{100}$ the difference of Latitude; the same distance will reach from the Sine of 90, to the Sine of 33 deg. 45 min. the Compl. Rhomb.

By the Logarithms. As the distance on the Rhomb A C 57 Leagues——1.75587

Is to the Difference of Latitude $31\frac{67}{100}$ Leagues A B——1.50065
So is the Sine of 90 deg.——10.00000

To the Sine Compl. of the Rhomb 33 deg. 45 min. the Sum——11.50065
The first Number subtract——1.75587

The Sine of the Angle A D E——9.74478

The Sine Compl. of the Rhomb 33 deg. 45, subtracted from 90 deg. there remains the Angle of the Rhomb 56 deg. 15 min. which is five Points, namely S. W. by W.

VI. *Sailing upon some Rhomb between the S. and the W.* 57 *Leagues, and finding I have altered my Latitude* $31\frac{67}{100}$ *Leagues, I demand my Departure from my first Meridian?*

By the Traverse-Table.

Against 57 Leagues in the Column of Distance Sailed, and in that Line or Angle of Meeting: find $31\frac{67}{100}$ Leagues, and in the Column to the left hand you will have $47\frac{39}{100}$ the Departure from the Meridian.

Distance run A C 57 Leagues } Sum $88\frac{67}{100}$ Leagues——1.94777
Diff. of Lat. A B $31\frac{67}{100}$ Leagues } Remain $25\frac{33}{100}$ Leagues——1.40363

3.35140

Departure from the Meridian B C $47\frac{39}{100}$ Leagues——1.67570

Which is thus done. To the Distance run, add the Difference of Latitude, and also subtract it from the same, noting the Sum and Remainder; then add together the Log. of this Sum and Remain, and half that Sum is the Log. of the Departure from the first Meridian.

CHAP. II.

What must be observed by all that keep account of a Ships Way at Sea, and to find the true Point of the Ship at any time, according to the Plain Chart.

I Might have further inlarged and multiplied Questions, but that I think these sufficient for any use at present; and therefore I will be brief, and come to the most material Business, (*viz.*)

The whole Practice of the *Art of Navigation*, in keeping of a right reckoning, consists chiefly of three Members or Branches.

First, In a well experienced Judgment, in estimating the Ship's Way or Distance Sailed upon every Shift of Wind.

Secondly, In duly estimating the Course or Point of the Compass on which the Ship hath made her way good; allowing for Lee-way Currents, and the Variation of the Compass.

Thirdly, The diligent taking all Opportunities of due observing the Latitude.

The Reckoning arising out of the two first Branches, we call our Dead Reckoning; and of these three Branches there ought to be such an Harmony and Agreement, that any two being given, a third may be found with Truth.

As, Having the Course and Distance, to find the Latitude of the Ship's Place.

Or, By the Course and Difference of Latitude, to find the Distance.

Or, by the Difference of Latitude and Distance to find the Course. But

But in the midst of so many uncertainties that daily occur in the Practice of Navigation, a joint Consent in these three Particulars, is hardly to be expected; and when an Error ariseth, the sole Remedy to be trusted to, is the Observation of the Latitude, and how to rectifie the Reckoning by the observed Latitude, we shall shew hereafter.

LOG-BOARD.

Hours.	*Course.*	*Knots.*	*Half Knots.*	*Fath.*	*Wind.*
2	S. E. b. S.	7	$\frac{1}{2}$	2	N.
4	S. S. W.	6	$\frac{1}{2}$		
6	E. b. N.	9			N.b.W.
8	N. b. E. $\frac{1}{2}$ E.	8			N. W.
10	N.N.W. $\frac{1}{2}$ W	7	$\frac{1}{2}$		E. N. E.
12	W.N. W.	9			N. E.
2	S. E. b. S.	8	$\frac{1}{2}$	2	
4	S. S. W.	7	$\frac{1}{2}$		E.
6	S. W. b. S.	6			E. S. E.
8	S. W.	9			S. E.
10	S. W.	8	$\frac{1}{2}$	3	S.b. E. $\frac{1}{2}$ E.
12	S. E.	9			S.bW. $\frac{1}{2}$ W.

But first of all it is most necessary to shew how we do keep our Reckoning at Sea, by the Log-Board, and take an account in our *Journal.*

In the Log-Board, The first Column is for Time.

The second for the Ships Course.

The third for the Knots.

The fourth for the Half-Knots.

The fifth for the Fathoms

The sixth is to put down the Wind, and thereby to give allowance to your Course, according to the Lee-way you have made by taking in or having out more Sail.

The Italian Mile by which we reckon at Sea, contains 1000 Paces, and each Pace 5 Foot, and every Foot 12 Inches; the 120 part of that Mile is $41\frac{2}{3}$ Feet, and so much is the space between the Knots upon the Log-line: So many Knots as the Ship runs in half a min. so many Miles she Saileth in an hour; or so many Leagues and so many Miles she runneth in a Watch, which is four hours, the time in which half the Company belonging to the Ship watch by turns.

Example. Nine Knots in half a min. is nine Miles in an hour, which is nine Leagues and nine Miles in a Watch, that is 12 Leagues or 25 Miles every Noon, after the Master and Mates have observed the Sun's Altitude, (if fair Weather) they take the Reckoning from the Log-board, and double the Knots run, which is the Number of Miles run upon any Course.

We throw the Log every two hours, and we never express the Course steered nearer than half a Point of the Compass.

Norwood gives full satisfaction in his *Seaman's Practice*, by his own Experience, That in our ordinary Practice at Sea, we cannot, if we will yield Truth the Conquest, allow less than 360000 of our English Feet to vary one deg. of Latitude in sailing N. or S. under any Meridian. According to this Measure, there will be in a deg. $68\frac{2}{11}$ of Miles of our Statute-Measure, each Mile 5280 Feet, and by the common Sea-measure 5000 Feet to a Mile, there will be 72 Miles, or 24 Leagues in a deg. which we will take for Truth. Now if you would have shewn the Miles of a true deg. allowing 60 to a deg. the Miles must be enlarged proportionably, and the distance between every one of the Knots must be 50 Foot, and as many of these as run out in half a m. so many miles or m. the Ship saileth in an hour; and for every 5 Foot more, you must allow the 10th part of a mile. Sailing between any two Places, and using a Log-line that hath a Knot at every 7 Fathoms; and to reduce it into such miles 60 to a deg. each containing 6000 Feet, the Proportion in number of these two is this, as 6 to 5; for 6 Knots of 6 Fathoms $\frac{2}{7}$, make 5 of $8\frac{1}{3}$ Fathoms, or 50 Feet. Admit a Man keeps a reckoning of his Ship by a Log-line of 6 Fathom $\frac{2}{7}$ and by it find the distance of two Places 1524 miles, or 508 Leagues, and would know the distance by a Log-line of 50 Feet to a Knot, or 6000 Feet to a mile.

Say then by the Rule of Proportion; as 6 is to 5: So is 1524 to 1270 miles.

Next we will work the Courses of the Log-board, and by it find the difference of Latitude and departure from the first Meridian.

A Ship being in the Lat. of 47 deg. 30 min. North, and Longitude 60 deg. the Courses of the Log-board are S. E b. S. 16 miles, and S.S. W. 13 miles, E. b. N. 18 miles, and N. b. E. $\frac{1}{2}$ E. 16 miles, N. N. W. $\frac{1}{2}$ W. 15 miles, and W. N. W. 18 miles, and S. E. b. S. 18 miles, and S. S. W. 15 miles, S. W. b. S 12 miles, and S. W. 18 miles, S. E. 18 miles by the Wind, which are W. S. W. and E. S. E. the Ship made 14 Points and a half Lee-way on the two last Courses.

To

To find the difference of Latitude and Departure from the Meridian this 24 hours.

There are ſeveral ways to work Traverſes ; but the readieſt is by the Traverſe-Scale, or the following Table ; I ſhall work the former Traverſe by the Tables following, and you at leaſure may work it by the Traverſe-Scale, and find the near agreement of both.

Courſe by Compaſs.	Miles ſail'd	North. Miles.	North. Parts.	South. Miles.	South. Parts.	Eaſt. Miles.	Eaſt. Parts.	Weſt. Miles.	Weſt. Parts.
S. E. b. S.	16			13	30	38	89		
S. S. W.	13			12	01			04	97
E. b. N.	18	03	51			17	65		
N. b. E. ½ E.	16	15	31			04	64		
N.N.W. ½ W.	15	13	23					07	07
W. N. W.	18	06	89					16	63
S. E. b. S.	18			14	97	10	00		
S. S. W.	15			13	86			05	74
S. W. b. S.	12			09	98			06	67
W. S. W.	18			06	89			16	63
E. S. E.	18			06	89	16	63		
Sum		38	94	77	90	57	81	57	71
Subtract leaſt				38	94	57	71		
Remains diff. Latitude.				38	96	00	10	*Depart.*	
The Latitude the Ship is in is 46 deg. 51 min.									

You muſt put down the Courſes made good upon each Point of the Compaſs, and Number of miles you find ſailed on them by the Log-board ; and make 4 other Columns and mark them with North, South, Eaſt, Weſt, in ſuch manner as I have done in this Table : Then according to the Rhombs look in the Table following for the Point, Half, or Quarter Sailed, and the diſtance in miles or Leagues in the right hand or left-hand Column, and put down the difference of Latitude and Departure under the North or South, Eaſt or Weſt Columns, according to the following Directions. *Examp.* The firſt Courſe failed is three Points from the Meridian ; namely, S. E. b. S. under that Column I count 16 miles in the ſide, and find againſt it 13$\frac{30}{100}$ miles Southing, 8$\frac{89}{100}$ miles Eaſting, becauſe the Courſe is South Eaſterly. I put it down in the Table in its place, 13. 30 under South, 8. 89 under Eaſt. In the like manner you do by the reſt. Likewiſe the laſt Courſe is E. S. E. that is 6 from the South ; therefore I reckon them in the foot of the Table, and right againſt 18 I find 06. 89 Southward, and 16. 63 Eaſtward, which you may put down as I have done in the Table. In the like manner you muſt do if your Courſe were Northweſting. This is ſo plain it needs no farther Precept. Then add up the Sums in the North, South, Eaſt and Weſt Columns, and ſubtract the leſſer out of the greater, the remainder is the difference of Latitude and Departure: As that I find the Ship hath gone but 38$\frac{96}{100}$ miles to the Southward, and the Latitude ſhe now is in is 46 deg. 51 min. and the Eaſtward but $\frac{10}{100}$ parts of a mile : Therefore her Courſe is near South.

CHAP. III. *A Formal and Exact way of ſetting down and perfecting a Sea-Reckoning.*

The Rule of keeping a perfect Sea-Reckoning, is beſt ſet down in particular after the general true Sea-Chart, in Chap. 17. *of* Great-Circle-Sailing.

THis being the moſt neceſſary Rule in this Art of Navigation, How to keep an exact Reckoning : Although the Courſe and Diſtance cannot be ſo truly ond certainly known as the Latitude may be ; yet we muſt endeavour in the theſe alſo to come as near the Truth as be; the rather, for that ſome Reckonings muſt neceſſarily depend wholly upon them. Therefore we come now to ſhew an Orderly and Exact way of framing and keeping a Reckoning at Sea ; for which purpoſe I have inſerted this Table following, which ſheweth how much a Ship is more Northerly or Southerly, and how much Eaſterly or Weſterly, by Sailing upon any Point or Quarter-point of the Compaſs, any diſtance or number of Miles or Leagues propoſed.

Note, If the diſtance ſailed exceed 100 Miles or Leagues, you muſt enter the Table twice or ofmer ; as in the following Ezample. Suppoſe a Ship ſails away South, half a Point Weſterly 173 Leagues or Miles ; we ſet down this Number thus.

Courſe	Diſtance.	Southing.	Weſting.
South	100	9951	980
½ Point W	70	6966	686
	3	298	29
Leagues.	173	17215	1695

Look into the firſt Column for the holf. Point, and then in the third Column you may ſee 980 ; alſo againſt 70, there is 6966, and in the ſecond 686; and in the third againſt 3 in the firſt Column is 298, in the ſecond is $\frac{29}{100}$.

Theſe ſummed up as iu the Table, ſhews that the Ship ſailing upon the firſt half Point from the Meridian, namely S. ½ W. is to the Southwards of the Place ſhe departed 172 $\frac{15}{100}$ Leagues or Miles, and to the Weſtward 16 Leagues and $\frac{95}{100}$.

A

A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass; to the 100 part of a League or Mile; which gives the Diff. of Lat. and Depar. from the Meridian.

Diff. in Leag. or miles fail'd.	2 d. 49 m.		5 d. 37 m.		8 d. 26 m		11 d. 15 m.		Diff. in Leag. or miles fail'd.
	0 Point ¼		0 Point ½		0 Point ¾		1 Point.		
	N S	E W	N S	E W	N S	E W	N S	E W	
1	01 00	00 05	01 00	00 10	00 98	00 14	00 98	00 20	1
2	02 00	00 10	01 99	00 20	01 97	00 29	01 96	00 39	2
3	03 00	00 15	02 88	00 29	02 96	00 44	02 94	00 58	3
4	04 00	00 20	03 98	00 39	03 95	00 58	03 92	00 78	4
5	05 09	00 25	04 97	00 49	04 94	00 73	04 90	00 98	5
6	05 99	00 29	05 97	00 59	05 93	00 88	05 88	01 17	6
7	06 99	00 34	06 97	00 69	06 92	01 02	06 86	01 37	7
8	07 99	00 39	07 96	00 78	07 91	01 17	07 85	01 56	8
9	08 99	00 44	08 96	00 88	08 90	01 32	08 83	01 76	9
10	09 99	00 49	09 95	00 98	09 89	01 46	09 81	01 95	10
11	10 98	00 54	10 95	01 08	10 88	01 61	10 79	02 15	11
12	11 98	00 59	11 94	01 18	11 87	01 76	11 77	02 34	12
13	12 98	00 63	12 94	01 27	12 86	01 91	12 75	02 54	13
14	13 98	00 68	13 93	01 37	13 85	02 05	13 73	02 73	14
15	14 98	00 73	14 93	01 47	14 84	02 20	14 71	02 19	15
16	15 98	00 78	15 92	01 57	15 83	02 34	15 69	03 12	16
17	16 98	00 83	16 92	01 67	16 82	02 49	16 67	03 32	17
18	17 97	00 88	17 91	01 76	17 80	02 64	17 65	03 51	18
19	18 97	00 93	18 91	01 86	18 79	02 79	18 64	03 71	19
20	19 97	00 98	19 90	01 96	19 78	02 93	19 62	03 90	20
21	20 97	01 03	20 90	02 06	10 77	03 08	20 60	04 10	21
22	21 97	01 08	21 98	02 16	21 76	03 22	21 58	04 29	22
23	22 97	01 13	22 98	02 25	22 75	03 37	22 56	04 49	23
24	23 97	01 17	23 88	02 35	23 74	03 52	23 54	04 68	24
25	24 97	01 22	24 88	02 45	24 73	03 66	24 52	04 88	25
26	25 96	01 27	25 87	02 55	25 71	03 81	25 50	05 07	26
27	26 96	01 32	26 87	02 65	26 70	03 96	26 48	05 27	27
28	27 96	01 32	27 86	02 75	27 69	04 10	27 46	05 46	28
29	28 96	01 42	28 86	02 84	28 68	04 25	28 44	05 66	29
30	29 96	01 47	29 86	02 94	29 67	04 40	29 42	05 85	30
31	30 96	01 52	30 85	03 04	30 66	04 55	30 40	06 05	31
32	31 96	01 57	31 85	03 14	31 65	04 69	31 38	06 24	32
33	32 96	01 61	32 84	03 23	32 64	04 84	32 37	06 44	33
34	33 95	01 66	33 84	03 33	33 63	04 98	33 35	06 63	34
35	34 95	01 71	34 83	03 43	34 62	05 13	34 33	06 83	35
36	35 95	01 75	35 83	03 53	35 61	05 28	35 31	07 02	36
37	36 95	01 81	36 82	03 63	36 60	05 42	36 29	07 22	37
38	37 95	01 86	37 82	03 73	37 59	05 57	37 27	07 41	38
39	38 95	01 91	38 81	03 82	38 58	05 72	38 25	07 61	39
40	39 95	01 96	39 81	03 92	39 57	05 87	39 23	07 80	40
41	40 95	02 01	40 80	04 02	40 55	06 02	40 21	08 00	41
42	41 95	02 06	41 80	04 12	41 54	06 16	41 19	08 19	42
43	42 95	02 11	42 79	04 21	42 53	06 31	42 17	08 39	43
44	43 94	02 15	43 79	04 31	43 52	06 45	43 15	08 58	44
45	44 94	02 20	44 78	04 41	44 51	06 60	44 14	08 78	45
46	45 94	02 25	45 78	04 51	45 60	06 75	45 12	08 77	46
47	46 94	02 30	46 77	04 61	46 49	06 89	46 10	09 17	47
48	47 94	02 35	47 77	04 70	47 48	07 04	47 08	09 36	48
49	48 94	02 40	48 76	04 80	48 47	07 20	48 06	09 56	49
50	49 94	02 45	49 76	04 90	49 46	07 33	49 04	09 75	50
51	50 93	02 50	50 75	05 00	50 44	07 48	50 02	09 95	51
52	51 93	02 55	51 75	05 10	51 43	07 63	51 00	10 14	52
53	52 93	02 60	52 74	05 20	52 42	07 77	51 98	10 34	53
54	53 93	02 65	53 74	05 29	53 41	07 92	52 96	10 53	54
55	54 93	02 70	54 73	05 39	54 40	08 07	53 94	10 73	55
56	55 93	02 75	55 73	05 49	55 30	08 21	54 92	10 92	56
57	56 93	02 79	56 72	05 59	56 38	08 36	55 90	11 12	57
58	57 93	02 84	57 72	05 68	57 37	08 51	56 89	11 31	58
59	58 91	02 89	58 71	05 78	58 36	08 65	57 87	11 51	59
60	59 92	02 94	59 71	05 88	59 35	08 80	58 85	11 70	60
70	69 91	03 43	69 66	06 86	69 24	10 27	68 65	13 65	70
80	79 90	03 92	79 61	07 84	79 13	11 73	78 46	15 60	80
90	89 89	04 41	89 56	08 82	89 02	13 20	88 27	17 55	90
100	99 87	04 90	99 51	09 80	98 91	14 67	98 08	19 50	100
200	199 76	09 89	199 02	19 90	197 82	29 34	196 16	39 00	200
	E W	N S	E W	N S	E W	N S	E W	N S	
	7 Points ¾		7 Points ½		7 Points ¼		7 Points		
	87 d. 11 m.		84 d. 22 m.		81 d. 34 m.		78 d. 45 m.		

A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass, in the 100 part of a League or Mile; which gives the Diff. of Lat. and Depar. from the Meridian.

Dist. in Leag. or miles sail'd	14 d. 04 m. — 1 Point ¼ — N S	E W	16 d. 52 m. — 1 Point ½ — N S	E W	19 d. 41 m. — 1 Point ¾ — N S	E W	22 d. 30 m. — 2 Points — N S	E W
1	00 97	00 24	00 96	00 29	00 94	00 33	00 92	00 38
2	01 94	00 48	01 91	00 58	01 88	00 67	01 85	00 76
3	02 91	00 72	02 87	00 87	02 82	01 01	02 77	01 75
4	03 88	00 97	03 83	01 16	03 77	01 34	03 70	01 53
5	04 85	01 21	04 78	01 45	04 71	01 68	04 62	01 91
6	05 82	01 45	05 74	01 74	05 65	02 02	05 54	02 30
7	06 79	01 70	06 70	02 03	06 59	02 35	06 47	02 68
8	07 76	01 94	07 66	02 32	07 53	02 70	07 39	03 16
9	08 73	02 18	08 61	02 61	08 47	03 03	08 31	03 44
10	09 70	02 43	09 57	02 90	09 41	03 37	09 24	03 83
11	10 67	02 67	10 53	03 19	10 36	03 71	10 16	04 21
12	11 64	02 91	11 48	03 48	11 30	04 04	11 09	04 59
13	12 61	03 15	12 44	03 77	12 24	04 36	12 01	04 97
14	13 58	03 40	13 40	04 06	13 18	04 72	12 93	05 36
15	14 55	03 64	14 35	04 35	14 12	05 05	13 86	05 74
16	15 52	03 88	15 31	04 64	15 06	05 39	14 78	06 12
17	16 49	04 13	16 27	04 93	16 00	05 73	15 71	06 51
18	17 46	04 37	17 22	05 22	16 95	06 06	16 63	06 89
19	18 43	04 61	18 18	05 51	17 89	06 40	17 55	07 27
20	19 40	04 86	19 14	05 81	18 83	06 74	18 48	07 65
21	20 37	05 10	20 10	06 10	19 77	07 08	19 40	08 04
22	21 34	05 34	21 05	06 39	20 71	07 41	20 32	08 42
23	22 34	05 48	22 01	06 68	21 66	07 75	21 25	08 80
24	23 28	05 83	22 97	06 97	22 60	08 08	22 17	09 18
25	24 25	06 07	23 91	07 26	23 54	08 42	23 10	09 57
26	25 22	06 31	24 88	07 55	24 48	08 76	24 02	09 95
27	26 19	06 56	25 84	07 84	25 42	09 10	24 94	10 33
28	27 16	06 80	26 79	08 13	26 36	09 43	25 87	10 71
29	28 13	07 04	27 75	08 42	27 30	09 77	26 79	11 10
30	29 10	07 28	28 71	08 71	28 25	10 11	27 72	11 48
31	30 07	07 53	29 66	09 00	29 19	10 44	28 64	11 86
32	31 04	07 77	30 62	09 29	30 13	10 74	29 56	12 25
33	32 01	08 01	31 58	09 58	31 07	11 12	30 40	12 63
34	32 98	08 26	32 54	09 87	32 01	11 45	31 44	13 01
35	33 95	08 50	33 49	10 16	32 95	11 79	32 34	13 39
36	34 92	08 74	34 45	10 45	33 89	12 13	33 26	13 78
37	35 89	08 99	35 41	10 74	34 84	12 47	34 18	14 16
38	36 86	09 23	36 36	11 03	35 78	12 80	35 11	14 54
39	37 83	09 47	37 32	11 32	36 72	13 14	36 03	14 92
40	38 80	09 71	38 28	11 61	37 66	13 48	36 96	15 31
41	39 77	09 96	39 23	11 90	38 60	13 81	37 88	15 69
42	40 74	10 20	40 19	12 19	39 54	14 15	38 80	16 07
43	41 71	10 44	41 15	12 48	40 49	14 49	39 73	16 45
44	42 68	10 69	42 12	12 77	41 43	14 72	40 65	16 84
45	43 65	10 93	43 06	13 06	42 37	15 16	41 57	17 22
46	44 62	11 17	44 02	13 35	43 41	15 50	42 50	17 60
47	45 59	11 41	44 98	13 64	44 25	15 83	43 42	17 99
48	46 56	11 66	45 93	13 93	45 19	16 17	44 35	18 37
49	47 33	11 90	46 89	14 22	46 13	16 37	45 27	18 75
50	48 50	12 14	47 85	14 51	47 08	16 85	46 19	19 13
51	49 47	12 39	48 80	14 80	48 02	17 18	47 12	19 52
52	50 44	12 63	49 76	15 09	48 96	17 51	48 04	19 89
53	51 41	12 87	50 72	15 38	49 90	17 85	48 97	20 28
54	52 38	13 11	51 67	15 67	50 84	18 19	49 89	20 66
55	53 35	13 36	52 63	15 96	51 78	18 53	50 01	
56	54 32	13 60	53 59	16 26	52 73	18 87	51 73	21 15
57	55 29	13 85	54 55	16 55	53 67	19 20	52 66	21 43
58	56 26	14 09	55 50	16 84	54 61	19 54	53 58	21 81
59	57 23	14 33	56 46	17 23	55 55	19 87	54 21	22 20
60	58 20	14 57	57 42	17 42	56 49	20 21	55 43	22 58
70	67 90	17 00	66 90	20 31	65 90	23 58	64 67	26 78
80	77 60	19 41	76 55	23 22	75 32	26 95	73 91	30 61
90	87 30	21 88	86 10	26 12	84 73	30 29	83 14	34 44
100	97 00	24 20	95 69	29 02	94 15	33 68	92 38	38 26
200	194 00	48 58	191 38	58 04	188 30	67 36	184 76	76 52
	E W	N S	E W	N S	E W	N S	E W	N S
	6 Points ¾ — 75 d. 56 m.		6 Points ½ — 73 d. 07 m.		6 Points ¼ — 70 d. 19 m.		6 Points. — 67 d. 30 m.	

55 43
22 92
56 35

22:5
22:3
22 9

5436
42

36/17

A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass, to the 100 part of a League or Mile; which gives the Diff. of Lat. and Depar. from the Meridian.

Dist. in Leag. or miles sail'd	25 d. 19 m. 2 Points ¼ N S	25 d. 19 m. 2 Points ¼ E W	28 d. 07 m. 2 Points ½ N S	28 d. 07 m. 2 Points ½ E W	30 d. 56 m. 2 Points ¾ N S	30 d. 56 m. 2 Points ¾ E W	33 d. 45 m. 3 Points N S	33 d. 45 m. 3 Points E W	Dist. in Leag. or miles sail'd
1	00 90	00 43	00 88	00 47	00 86	00 51	00 83	00 56	1
2	01 81	00 85	01 76	00 94	01 71	01 03	01 66	01 55	2
3	02 71	01 28	02 65	01 41	02 57	01 54	02 49	01 67	3
4	03 61	01 71	03 53	01 89	03 43	02 06	03 32	02 22	4
5	04 52	02 14	04 41	02 36	04 29	02 57	04 16	02 78	5
6	05 42	02 56	05 29	02 83	05 15	03 08	04 99	03 33	6
7	06 33	02 99	06 17	03 30	06 00	03 60	05 82	03 89	7
8	07 23	03 42	07 05	03 77	06 86	04 11	06 65	04 44	8
9	08 14	03 85	07 94	04 24	07 72	04 63	07 48	05 00	9
10	09 04	04 28	08 82	04 71	08 58	05 14	08 31	05 55	10
11	09 94	04 70	09 70	05 18	09 44	05 66	09 15	06 11	11
12	10 85	05 13	10 58	05 66	10 29	06 17	09 98	06 67	12
13	21 75	05 56	11 46	06 13	11 15	06 68	10 81	07 22	13
14	12 66	05 99	12 35	06 60	12 00	07 20	11 64	07 78	14
15	13 56	06 41	13 23	07 07	12 87	07 71	12 47	08 33	15
16	14 46	06 84	14 11	07 54	13 72	08 23	13 30	08 89	16
17	15 37	07 27	14 99	08 01	14 58	08 74	14 13	09 44	17
18	16 27	07 70	15 87	08 48	15 44	09 25	14 97	10 00	18
19	17 18	08 12	16 76	08 96	16 30	29 77	15 80	10 56	19
20	18 08	08 55	17 64	09 43	17 16	10 28	16 63	11 11	20
21	18 98	08 98	18 52	09 90	18 01	10 80	17 46	11 67	21
22	19 89	09 41	19 40	10 37	18 87	11 31	18 29	12 22	22
23	20 79	09 83	20 28	10 84	19 73	11 82	19 12	12 78	23
24	21 60	10 26	21 17	11 31	20 59	12 34	19 95	13 33	24
25	22 60	10 69	22 05	11 78	21 44	12 85	20 79	13 89	25
26	23 50	11 12	22 93	12 26	22 30	13 37	21 62	14 44	26
27	24 41	11 54	23 81	12 73	23 16	13 88	22 45	15 15	27
28	25 31	11 97	24 69	13 20	24 02	14 39	23 28	15 56	28
29	26 22	12 40	25 58	13 67	24 87	14 91	24 11	16 11	29
30	17 12	12 83	26 46	14 14	25 73	15 42	24 94	16 67	30
31	28 02	13 25	27 34	14 61	26 59	15 94	25 78	17 22	31
32	28 93	13 68	28 22	15 08	27 45	16 45	26 61	17 78	32
33	29 83	14 11	29 10	15 56	28 31	16 97	27 44	18 33	33
34	30 74	14 54	29 98	16 03	29 16	17 48	28 27	18 89	34
35	31 64	14 96	30 87	16 50	30 02	17 99	29 10	19 44	35
36	32 54	15 39	31 75	16 97	30 88	18 51	29 93	20 00	36
37	33 45	15 82	32 63	17 44	31 74	19 02	30 76	20 56	37
38	34 35	16 25	33 57	17 91	32 59	19 54	31 60	21 11	38
39	35 26	16 68	34 40	18 38	33 45	20 05	32 43	21 67	39
40	36 16	17 10	35 28	18 86	34 31	20 56	33 26	22 22	40
41	37 06	17 53	36 16	19 34	35 17	21 08	34 09	22 78	41
42	37 67	17 96	37 04	19 81	36 02	21 59	34 92	23 34	42
43	38 87	18 38	37 92	20 27	36 88	22 11	35 75	23 89	43
44	39 78	18 81	38 80	20 74	37 74	22 62	36 58	24 44	44
45	40 68	19 24	39 69	21 21	38 60	23 14	37 41	25 00	45
46	41 51	19 67	40 57	21 68	39 46	23 65	38 25	25 56	46
47	42 49	20 09	41 41	22 16	40 31	24 16	39 08	26 11	47
48	43 39	20 52	42 43	22 63	41 17	24 68	39 91	26 67	48
49	44 30	20 95	43 21	23 10	42 03	25 19	40 74	27 22	49
50	45 20	21 38	44 10	23 57	42 89	25 71	41 57	27 78	50
51	46 10	21 61	44 98	24 04	43 74	26 22	42 40	28 33	51
52	47 01	22 23	45 86	24 51	44 60	26 73	43 24	28 89	52
53	47 91	22 66	46 74	24 98	45 46	27 25	44 07	29 44	53
54	48 82	23 08	47 62	25 46	46 32	27 76	44 90	30 00	54
55	49 72	23 52	48 51	25 93	47 17	28 28	45 73	30 56	55
56	50 62	23 94	49 39	26 40	48 03	28 79	46 56	31 11	56
57	51 53	24 37	50 27	26 87	48 89	29 30	47 39	31 67	57
58	52 43	24 79	51 15	27 34	49 75	29 82	48 22	32 22	58
59	53 33	25 23	52 03	27 81	50 61	30 33	49 06	32 78	59
60	54 24	25 65	52 91	28 28	51 46	30 84	49 89	33 33	60
70	63 27	29 92	61 73	32 99	60 04	35 98	58 21	38 88	70
80	72 31	34 20	70 55	37 71	68 61	41 12	66 51	44 44	80
90	81 35	38 47	79 37	42 43	77 19	46 26	74 83	50 00	90
100	90 39	42 75	88 19	47 13	85 77	51 41	83 14	55 55	100
200	180 78	85 50	176 38	94 26	171 54	102 82	166 28	111 11	200
	E W	N S	E W	N S	E W	N S	E W	N S	
	5 Points ¾		5 Points ½		5 Points ¼		5 Points		
	64 d. 42 m.		61 d. 52 m.		59 d. 04 m.		56 d. 15 m.		

66:51: 44:44
1:66: 1:55
68:17 45:99

58:22
1:23
59:45

38 88
56
39 44

19 60

54:34
42
55.16

193
234

41:57: 17 22
46:19: 19:15
87:76: 36:3

58:22
4:99
63:21

38 88
3:83
42 71

83:14 55:55
5.31 5:55
91:45:61:10

A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass, to the 100 part of a League or Mile; which gives the Diff. of Lat. and Depar. from the Meridian.

Dist. in Leag. or miles fail'd	36 d. 34 m.		39 d. 22 m.		42 d. 11 m.		45 d. 00 m.	
	3 Points ½		3 Points ¾		3 Points ¼		4 Points	
	N S	E W	N S	E W	N S	E W	N S	E W
1	00 80	00 60	00 77	00 63	00 74	00 67	00 71	00 71
2	01 61	01 19	01 55	01 27	01 48	01 34	01 41	01 41
3	02 41	01 41	02 32	01 90	02 22	02 01	02 12	02 12
4	03 21	02 38	03 09	02 54	02 96	02 69	02 83	02 83
5	04 02	02 98	03 86	03 17	03 70	03 36	03 54	03 54
6	04 82	03 57	04 64	03 81	04 44	04 03	04 24	04 24
7	05 62	04 17	05 41	04 44	05 18	04 78	04 95	04 95
8	06 43	04 76	06 18	05 07	05 93	05 37	05 66	05 66
9	07 23	05 36	06 96	05 71	06 67	06 04	06 36	06 36
10	08 03	05 96	07 73	06 34	07 41	06 72	07 07	07 07
11	08 83	06 55	08 50	06 98	08 15	07 39	07 78	07 78
12	09 64	07 15	09 28	07 61	08 89	08 06	08 49	08 49
13	10 44	07 74	10 05	08 25	09 63	08 73	09 19	09 19
14	11 24	08 34	10 82	08 88	10 37	09 40	09 90	09 90
15	12 05	08 94	11 60	09 52	11 11	10 07	10 61	10 61
16	12 85	09 53	12 37	10 15	11 85	10 74	11 31	11 31
17	13 66	10 13	13 14	10 78	12 70	11 42	12 02	12 02
18	14 46	10 72	13 91	11 42	13 34	12 09	12 73	12 73
19	15 26	11 32	14 69	12 04	14 08	12 76	13 44	13 44
20	16 06	11 91	15 41	12 69	14 82	13 43	14 14	14 14
21	16 87	12 51	16 23	13 32	15 56	14 10	14 85	14 85
22	17 67	13 11	17 01	13 96	16 30	14 77	15 56	15 56
23	18 47	13 70	17 78	14 59	17 04	15 45	16 26	16 26
24	19 28	14 30	18 55	15 22	17 78	16 12	16 97	16 97
25	20 08	14 89	19 32	15 86	18 52	16 79	17 68	17 68
26	20 88	15 49	20 10	16 49	19 26	17 46	18 38	18 38
27	21 69	16 09	20 87	17 13	20 00	18 13	19 09	18 09
28	22 49	16 68	21 64	17 76	20 75	18 79	19 80	19 80
29	23 29	17 27	22 42	18 40	21 49	19 44	20 51	20 51
30	24 10	17 87	23 19	19 03	22 23	20 12	21 21	21 21
31	24 90	18 47	23 96	19 67	22 97	20 81	21 92	21 92
32	25 70	19 06	24 74	20 30	23 71	21 49	22 63	22 63
33	26 51	19 66	25 51	20 93	24 45	22 16	23 33	23 33
34	27 31	20 25	26 28	21 57	25 19	22 83	24 04	24 04
35	28 11	20 85	27 06	22 20	25 93	23 50	24 75	24 75
36	28 91	21 46	27 83	22 84	26 67	24 17	25 46	25 46
37	29 72	22 04	28 60	23 47	27 41	24 85	26 16	26 16
38	30 52	22 64	29 37	24 11	28 16	25 52	26 87	26 87
39	31 33	23 23	30 15	24 74	28 90	26 19	27 56	27 56
40	32 13	23 83	30 92	25 38	29 64	26 86	28 28	28 28
41	32 93	24 42	31 69	26 01	30 38	27 53	28 99	28 99
42	33 73	25 02	32 47	26 64	31 12	28 21	29 10	29 10
43	34 54	25 61	33 24	27 28	31 86	28 88	30 41	30 41
44	35 34	26 21	34 01	27 91	32 60	29 55	31 11	31 11
45	36 14	26 81	34 78	28 55	33 34	30 22	31 82	31 82
46	36 94	27 40	35 56	29 18	34 08	30 89	32 53	32 53
47	37 75	28 00	36 33	29 81	34 82	31 56	33 23	33 23
48	38 55	28 59	37 10	30 45	35 57	32 23	33 94	33 94
49	39 36	29 19	37 88	31 08	36 31	32 91	34 65	34 65
50	40 17	29 78	38 65	31 72	37 05	33 58	35 35	35 35
51	40 96	30 38	39 42	32 35	37 79	34 25	36 06	36 06
52	41 77	30 98	40 20	32 99	38 53	34 92	36 77	36 77
53	42 57	31 57	40 97	33 62	39 27	35 59	37 48	37 48
54	43 37	32 17	41 74	34 26	40 01	36 26	38 14	38 14
55	44 18	32 76	42 52	34 86	40 75	36 94	38 89	38 89
56	44 98	33 36	43 29	35 53	41 49	37 61	39 60	39 60
57	45 78	33 96	44 06	36 16	42 23	38 28	40 30	40 30
58	46 59	34 55	44 83	36 79	43 07	38 95	41 01	41 01
59	47 39	35 15	45 61	37 43	43 72	39 62	41 72	41 72
60	48 19	35 74	46 38	38 06	44 45	40 29	42 43	42 43
70	56 22	41 69	44 11	44 41	51 85	47 00	49 49	49 49
80	64 25	47 65	61 84	50 75	59 26	53 72	56 56	56 56
90	72 28	53 61	69 57	57 09	66 67	60 44	63 63	63 63
100	80 32	59 56	77 30	63 43	74 08	67 15	70 71	70 71
200	160 69	199 12	154 60	126 86	148 16	134 30	141 41	141 41
	E W	N S	E W	N S	E W	N S	E W	N S
	4 Points ¾		4 Points ½		4 Points ¼		4 Points	
	53 d. 26 m.		50 d. 37 m.		47 d. 49 m.		45 d. 00 m.	

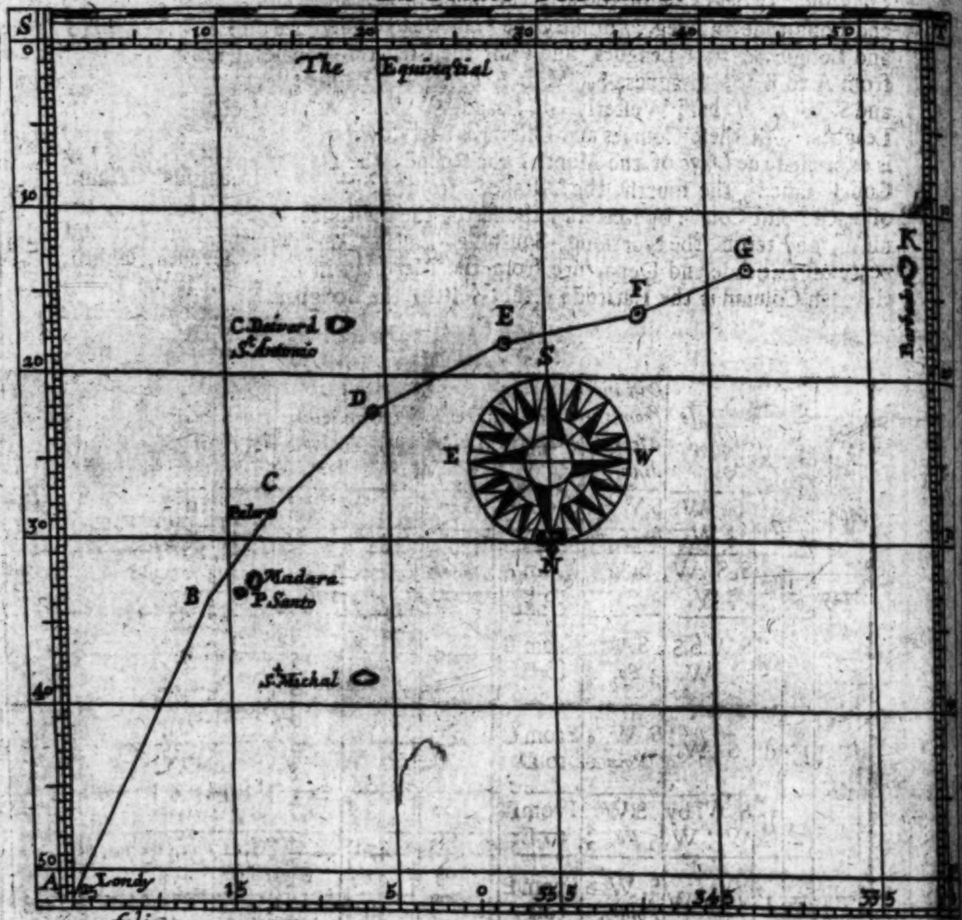
Another Example I will give of a supposed Reckoning between Lundy *and* Barbadoes.

Suppose a Ship sail from the Island of *Lundy*, in Latitude 51 deg. 22 min. North, and Longitude 25 deg. 52 min. towards the Island of *Barbadoes*, in Latitude 13 deg. 10 min. N. and Longitude 332 deg. 57 min. By the *Plain Chart*, Difference of Latitude is 764 Leagues, and Longitude 1058 Leagues, and I sail these several Courses, (*viz.*) S. S. W. half W. from A to B 400 Leagues, S. W. b. S. half W. 125 Leagues, and S. W. 192 Leagues; and S. W. b. W. half Westerly 190 Leagues; W. S. W. 146 Leagues, and W. b. S. 159 Leagues. All these Courses and Distances I set down as followeth. In the first Column is expressed the Days of the Month; the second, the Day of the Week; the third, the Course sailed; the fourth, the Distance from the Meridian; the fifth, the Place and of each Point Course by Letters; the sixth, the Distance sailed; the seventh, eighth, ninth, and tenth, the Northing, Southing, Easting, and Westing, which is the Difference of Latitude and Departure from the Meridian in Leagues and tenth parts; the eleventh Column is the Latitude; the twelfth, the Longitude.

	Da. Month.	*Da. Week.*	*Course sailed.*	*Distance from the Meridian.*	*The Places.*	*Dist. Sailed.*	*Northing.*	*Southing.*	*Easting.*	*Westing.*	*Latitu. deg.*	*Latitu. min.*	*Longit. deg.*	*Longit. min.*
Apr.	21	f	S. W. ½ W.	S. W. 54 d. 10 m.	From A to K.	1305 *Leagues*	*Leagu.*	764 *Leagu.*	*Leag.*	1058 *Leag.*	51 13	22 10	25 332	52 57
May	2	c	S. S. W ½ W.	S. W. 2 *Po.* ½	From A to B.	200 200		176 4 176 4		94 3 94 3	33	43	16	25
	6	G	S. W. b. S. ½ W.	S. W. 3 *Po.* ½	From B to C.	100 20 5		773 155 39		634 127 32	28	52	12	28
	10	d	S. W.	S. W. 4 *Points*	From C to D.	100 80 12		707 566 85		707 566 85	22	04	5	40
	15	b	S. W. by W. ½ W.	S. W. 5 *Po.* ½	From D to E.	100 90		471 424		882 794	17	34	357	16
	19	f	W. S. W	S. W. 6 *Points.*	From E to F.	100 40 6		383 153 23		924 370 55	14	46	350	31
	24	d	W. by S.	S. W. 7 *Points.*	From F to G.	100 50 9		195 98 18		981 490 88	13	13	342	43

Note, When we set sail, we put down the Day of the Month and Week, the direct Course to the Port we are bound to, and the Place marked with two Letters, as in this Table, A for *Lundy*, and K for *Barbadoes*; and also under Distance, the number of Leagues upon a strait Course; and under Northing or Southing, the Difference of Latitude in Leagues and tenth parts; and under Easting and Westing, the Departure in Leagues; and under Latitude, the Latitude of the two Places; and under Longitude, the Longitude of the two Places; which you may see in the Head of the Table, against the 21 of *April*. Now if you would set down this Reckoning on the *Plain Chart*, take these following Directions; and first how to describe the *Plain Chart*.

The Plaine Sea Chart.



folio

MAke the Square A S T B, of what length and breadth you pleaſe, and divide each ſide into as many equal parts repreſenting degrees, as your occaſion requires; and then draw ſtraight Lines through theſe parts, croſſing one the other at Right Angles, ſo making many little Geometrical Squares, each of which contain one deg. but I have made them here for want of room to contain 10 deg. So that you may make the Primary Meridian in your Chart 25 deg. 52 min. to the Weſtward of the Meridian of *Londy*, and you may divide the two Sides into Degrees as far as you think fit, and every deg. into 6 or 10 Parts as the Degrees will permit. This is ſo plain, it needs no further Precept; therefore we will proceed to the uſe of it.

Now your ſeveral Courſes and Diſtances are laid down on this Chart, from *Londy* at A, to B, the ſecond to C, the third to D, the fourth to E, the fifth to F, the ſixth to G, either by the Line of Chords on the Plain Scale, or elſe by the Protractor, deſcribed Page 639. Lay off your firſt Courſe from the Meridian A S, upon the Line A B, and lay off your Diſtance 400 Leagues or 20 Degrees (taken from the Chart) from A to B, then lay the edge of the Protractor parallel to the Meridian, A S, or any other; lay off your ſecond Courſe upon the Line B C, and your Diſtance in Degrees from B to C, and ſo proceed with the reſt, till you come to G, which is the place where the Ship is the 24th Day at Noon. But the place where the Ship is at any time, may be be more eaſily found by the help of the Table preceding, containing the Reckoning between *Londy* and the *Barbadoes*. In the ſaid Table you have the Latitude and Longitude the Ship is in every

every Day at Noon; so that the 24th Day the Ship is in the Lat. 13 d. 13 m. Northerly, and in the Longitude of 34 d. 43 m. Therefore setting your Compasses in the Longitude of *Landy*, extend the other Point to 342 d. 43 m. then setting one Point of your Compasses in the Latitude 13 d. 13 m. in the Meridian, passing through *Landy*, with the former extent, place the other Point parallel to an East and West Line, that Point of the Compasses shall shew the Place where the Ship is, which is G; whereby you will find the *Barbadoes* to bear West, and to be distant 180 Leagues or 9 Degrees.

CHAP. IV.

To Correct the Account, when the Dead Latitude differs from the Observed Latitude.

WE come now to make good what was promised in the Second Chapter, to prescribe four Precepts for correcting a single Course.

I shall be brief, following *Collins*, his *Mariner's Plain Scale*, who hath imitated *Metius* in these Examples.

Rule I. If a Ship sail under the Meridian, if the difference of the Latitude be less by Estimation, than it is by Observation, the Ship's Place must be corrected and enlarged under the Meridian; and the Error is to be imputed either to the Judgment in estimating the distance run, in making it too little; or if the said distance be well estimated with good Judgment, it is to be supposed you stem some Current.

Admit a Ship sail from A, in the Latitude of 36 deg. directly South, 70 Leagues, or 3 deg. 30 min. by Estimation, and so is at B, in the Latitude 32, 30, but by Observations he is in the Latitude 32 deg. The Reckoning rectified, the Ship's Place is in the Point C; but if the difference of Latitude be more by Estimation, than it is by Observation. In this Case, the distance is to be shortned, and the Correction must be made according to the Latitude observed under the Meridian.

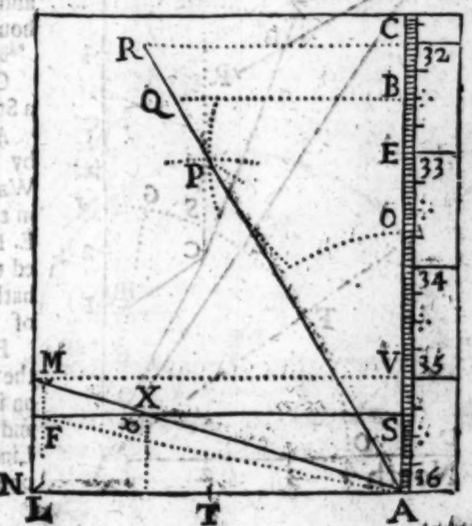
Admit a Ship sail South from A, in the Latitude 36 deg. until she have altered her Latitude 3 deg. 30 min. by Estimation being at B, in Latitude 32 d. 30 m. and if the observed Latitude be 33 d. 00 m. the Ship's Place corrected is at E, and not at B.

Rule II. Supposing no Current, If the Ship sail within 5 Points of the Meridian, and the Dead Latitude differ from the Observed Latitude, the Error is in misjudging the distance run, which is to be made longer or shorter as the Case requires.

Admit a Ship sail from A, S. S. E. ½ Easterly 70 Leagues, and is by Estimation at P in the Latitude of 33 deg. but if the observed Latitude be 32 deg. 30 min. admit at B, then a Line drawn through B, parallel to N A, crosseth the Line of the Ship's Course at Q, which is the corrected Point where the Ship is: So that the distance is enlarged 11 Leagues $\frac{7}{10}$, the whole distance A Q is 81 Leagues $\frac{6}{10}$.

The same manner, If a Ship had sailed 94 Leagues on the same Course, and by Estimation were at the Point R, in the Parallel of 32 deg. and by Observation the Latitude were found to be 32 deg. 30 min. In this Case the Ship's distance is be shortned, by drawing the aforesaid Line B Q parallel to N A; and it will cross the Line of the Ship's Course at Q, the corrected Point where the Ship is.

Rule III. Suppose there is some Current, if the Ship sail E. or W. but you can depend upon the observed difference of Latitude and Log-distance, as both true; then the Error may be imputed to the Rhomb, which alters by reason of the supposed Current. Then retain the observed difference of Latitude, and distance, and thereby find the Departure from the Meridian, by drawing a new Rhomb-Line. But if your Judgment would allot the Error to the distance, only keep the observed difference of Latitude: And the Course the same as was by the Dead-Reckoning.



Suppose a Ship sail E. by S. half a Point Southerly 69 Leagues, from the Latitude of 36 deg. from A to M, and by Dead-Reckoning should be in the Latitude of 35 deg. If the observed Lati-

tude

tude be 35 deg. 20 min. which is at S; in this Case, if the Error be wholly imputed to the distance, the Line S X being drawn parallel to N A, would cut off or shorten the distance as much as the Measure M X, which is 23 Leagues, which because it seems absurd and improbable, is not to be admitted of: Wherefore imputing the Error to the Rhomb only, with the extent A M, describe an Arch as at F, and extend the Parallel S X till it pass through the said Arch at F, then the Course is upon the Line A F, which is E. b. S. differing half a Point from the Course steered.

Rule IV. If a Ship sail E. or W. and the Dead and Observed Latitude do agree, the Reckoning cannot be corrected; but if they differ, impute the Error partly to the Rhomb and partly to the Distance; and so correct your Reckoning according to discretion.

By the Traverse-Scale.

Extend the Compasses from 100, to the distance Sailed; the same extent will reach from the Difference of Latitude by Observation, to the true Course: So that you may in a Moment do all these Questions and Cases by the Traverse-Scale, and Line of Numbers and Artificial Points and Quarters thereon. If you have but the perfect Use of it, I know there is no Instrument whatsoever more ready to resolve any useful Question and correct your Reckoning.

Lastly, If by frequent Observation you find the Ship is still carried from the East or West, either Northward or Southward, you may conclude some Current to be the cause thereof; Keep the Distance by Dead-Reckoning and Observation, and the Difference is the Distance from the Parallel. We will not multiply too many Examples, but rather advise the Ingenious to make use of such as his need shall require; for understanding what hath been said, will be advantagious to the Practitioner.

CHAP. V.

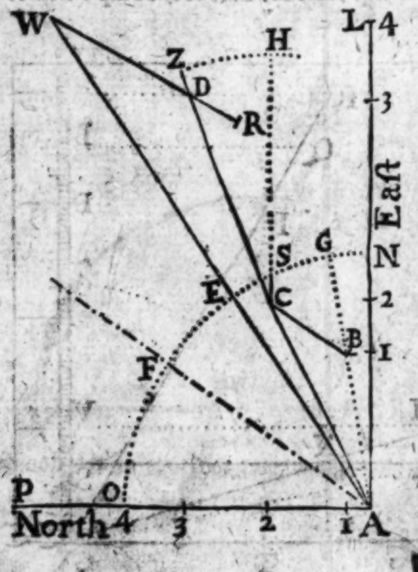
How to allow for known Currents, in Estimating the Ship's Course and Distance.

THis hath been largely handled by *Norwood*, in his *Seaman's Practice*; and by *Phillips*, as also how to [illegible] out by comparing the Reckoning homeward with the Reckoning outward, which was kept betwixt two Places: I shall be brief, and work by Scale and Compass, what they have done by Tables.

First, This is easie to be understood, if you sail against a Current, if it be swifter than the Ships way, you fall a stern; but if it be slower, you get on Head so much as the Difference between the way of the Ship, and the race of the Current.

1 *Example.* If a Ship sail 8 miles South in an hour, by Log or Estimation, against a Current that sets North 3 miles in an hour, that subtracted from 8, leaves 5 miles an hour the Ship goes a Head South: but if the Ships way were 3 miles an hour South, against a Current that sets 8 miles an hour North, the Ship would fall a Stern 5 miles an hour.

South 8 miles; Currrent 3 miles; Goes a Head 5 miles South.



Admit a Ship runs a Head 4 miles an hour, and the Current runs East also 3 miles an hour, What is the true motion of the Ship?

Answer, Seven miles an hour a Head.

Current 8 miles; Ships Way 3 miles; Falls a Stern 5 miles.

Admit a Ship cross a Current that sets N. E. by N. 4 miles an hour, the Ship sails in a Watch, or 4 hours, 9 Leagues E. by N. and in two Watches more she sails 13 Leagues E. N. E. by the Compass. Now it is required to find what Course and Distance the Ship hath made her Way good from the first place of setting out from A.

First draw the Right Line A L, then with the Chord of 60 deg. describe the Quadrant on it; Take 90 deg. of the Line of Chords, and lay it from N to O; then draw the North Line A P; then set off the Ships first Course one Point from the East from N to G, and draw

draw the Line A G, and from A to B lay off the first Distance 9 Leagues: then prick off the Course of the Current, being 5 Points from N to F, and draw the Line A F, being the Course N. E. by N. of the Current. And because the Current in 4 hours sets 5 Leagues three Quarters forward in its own Race, therefore draw the Line B C, parallel to A F, that is, take the nearest Distance from B to A F, and sweep a small Arch over the Line A F, and from B to the upper edge of the Arch, draw the Line B C, and thereon put from B to C 5 three Quarters, the Currents motion, and draw the Line A C; which shews the Course the Ship hath made good the first Watch. Now for the second Course draw C H parallel to the Line A L, and with the Radius or Chord of 60 deg. upon C as a Center, draw the Arch H Z, whereon prick 22 deg. 30 min. or 2 Points for E. N. E. for the Ship's second Course from the East; and draw C Z, whereon prick down the Distance sailed 13 Leagues from C to D; then draw D W parallel to A F as you did B C; then because the Current sets 10 $\frac{2}{3}$ in two Watches, therefore prick down 10 $\frac{2}{3}$ Leagues from D to W, and draw the Line A W; which being measured upon the same Scale (of an Inch divided into 10 parts) shews the Ship's direct distance is 35 Leagues and a half; whereas if there had been no Current, the direct distance had been A R 22 Leagues. Then measure the Arch N E, and you will find it 34 deg. which is a little above three Points from the East. So the Point the Ship hath made good is N. E. by E. a little Northerly; whereas if there had been no Current, the Course had been N. E. that is, East and by North half a Point Northerly.

Some will expect some other sort of Questions (besides these foregoing:) For them, at their leisure-time, I have inserted these Questions following.

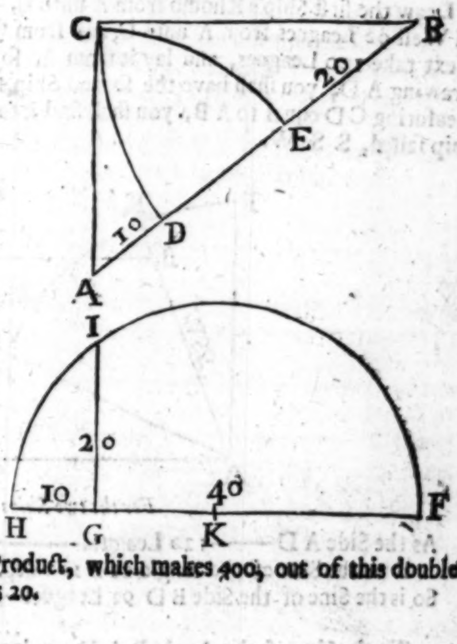
Quest. I. *A Ship sails 40 Leagues more than her Difference of Latitude, and is departed from the Meridian 80 Leagues; I demand her Difference of Latitude.*

Double the excess of the Distance above the Difference of Latitude, which makes 80, then to the Departure 80, add the said Excess 40, the Sum is 120; and likewise subtract the Excess from the Departure, the Difference is 40. Then say, By the Rule of Three.

As 80, to 120: So is 40. to 60. Which is the Difference of Latitude required.

This may be Geometrically performed by Problem 14. Book 1.

Quest. II. *A Ship sails 20 Leagues more than her Difference of Latitude, and 10 Leagues more than her Departure from the Meridian, I demand her Distance sailed.*

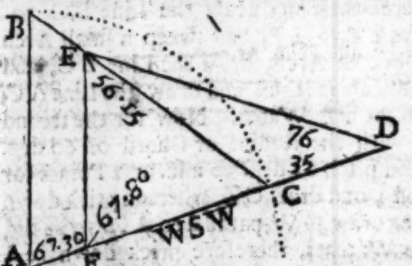


In the Triangle A B C, you have A B 20 Leagues more than the Difference of Latitude A C; and 10 Leagues more than the Departure from the Meridian B C.

First, With the double of either Number, which here I take, the double of E B 20, which is 40 Leagues, and lay from F unto G: then I take the other Number A D 10, and add it thereunto, as G H. Now on the midst of F H, as at K, making it the Center, I describe the Semicircle H I F. Then on G erect the Perpendicular which cuts the Arch in I: then measuring G I, it will be equal to D E 20 Leagues, which added to the two former Numbers 20 and 10, you have in all 50 Leagues for the distance sailed, required.

Arithmetically. Multiply A D 10, by B E 20, which produces 400, double this Product, which makes 400, out of this double Product Extract the Square Root, which is 20.

Quest. III. *Two Ships sail from one Port: The first sails directly S. the second Ship sails W. S. W. more than the first by 35 Leagues, and then were asunder 76 Leagues: The Question is, How many Leagues each Ship sailed.*



First draw the Meridian-line A B, and from A draw a W. S. W. Line, as A D, and from C, (where the Chord of 60 deg. cuts the Line A D) lay down the 35 Leagues unto D. Now draw the Chord-line BC; then take 76 Leagues, and lay it from D to cut the Chord-line in E.

Lastly, From E you must draw a Parallel Meridian, which will cut the Rhomb-line in F; so measuring E F, you shall have 45 Leagues and a half, that the first Ship sailed directly South: and the second Ship sailed 35 Leagues and a half more, that is 80 Leagues and a half, the distance required.

By the Artificial Tables of Sines and Numbers.

As the Side E D ———— 76 Leagues Co. Ar. ————	8.11919
To the Sine of the Angle E C D 123 deg. 45 min. ————	9.91933
So is the Side C D ———— 35 Leagues ————	1.54407
To the Sine of the Angle C E D 22 deg. 31 min. ————	9.58311

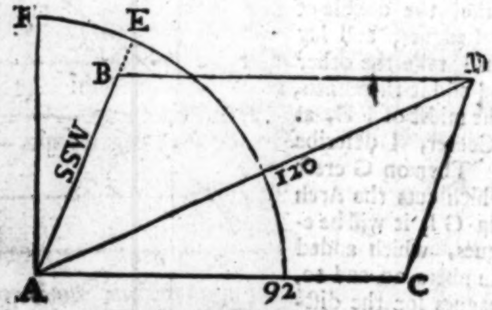
Which subtract from 56 deg. 15 min. you have the Angle at D 33 deg. 44 min.

Then, As the Sine of the Angle at F 67 deg. 30 min. Co. Ar. ————		0.03438
Is to his opposite Side ———— E D 76 Leagues	add	1.88081
So the Sine of the Angle at D 33 deg. 44 min. ————	add	9.74455
To his opposite Side ———— F E $45\frac{67}{100}$ Leagues ————		1.65974

So the first Ship sailed $45\frac{67}{100}$ Leagues; and the other $80\frac{67}{100}$ Leagues.

Quest: IV. *Two Ships sailed from one Port: The first sails S. S. W. a certain Distance; then altering her Course, she sails due West 92 Leagues: The second Ship sailing 120 Leagues meets with the first Ship, I demand the second Ship's Course, and how many Leagues the first Ship sailed S. S. W.*

Draw the first Ship's Rhomb from A unto E, being S. S. W. then lay her Distance sailed West 92 Leagues from A unto C, and from C draw a S. S. W. Line as C D continued: Next take 120 Leagues, and lay it from A, so that it shall cut the Line C D in D: So drawing A D, you shall have the second Ship's Course near West South West. Lastly, measuring C D equal to A B, you shall find it to be 49 Leagues and a half that the first Ship sailed, S. S. W.



For the two Ships Course.

As the Side A D ———— 120 Leagues ———— Co. Ar. ————	7.92082
Is to the Sine of the Angle at B 112 deg. 30 min. ————	9.96562
So is the Sine of the Side B D 92 Leagues ————	1.96379
To the Sine of the Angle B A D 45 deg. 6 min. ————	9.85023

Unto

Unto which add the Angle F A B 22 deg. 30 min. you have the second Ship's Rhomb 67 deg. 36 min. being near W. S. W. whose Complement is the Angle A D B 22 deg. 24 min.

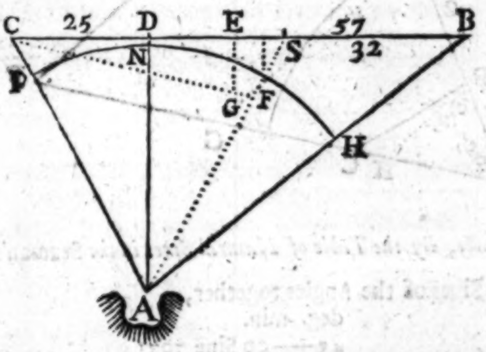
For the distance of the Ships.

As the Sine of the Angle——B A D 45 deg. 6 min. Co. Ar.——0.14976
Is to the Side——B D 92 Leagues——1.96379
So is the Sine of the Angle——A D B 22 deg. 24 min.——9.58101

To the Side A B 49 $\frac{5}{10}$ Leagues required——1.69456

Quest. V. *Two Ships sail from one Port upon two Courses 7 Points asunder: The one sails in the* S. W. *Quadrant, and departs from the Merid.* 57 *Leagues; and the other sailed in the* S. E. Quadrant, *and was departed from the Meridian but* 25 *Leagues, and then are both fallen into one Latitude; I demand the Rhomb or Courses of each Ship.*

First draw an East and West Line continued; and making choice of a Point at D, upon D erect a Perpendicular, which will be a Meridian-line, as D A continued. Now from D lay down the West Ship's Departure D B 57 Leagues; also the East Ship's Departure 25 Leagues D C: So their whole distance will be C B 82 Leagues. Now upon the Point at B, or else as here at C, draw an Angle of the Complement, of 7 Points, that is 1 Point, as C F the prickt Line.



Now from the midst between B and C, at E, draw another Meridian-Line, until it cut the former Rhomb-line C F in the Point G: So taking the distance from the Point G unto C, lay the same from G, until it cut the Meridian-line, in the Point A, which is the Place or Port you sailed from.

Lastly, From A you shall draw their Rhombs or Courses, as A B, which is $4\frac{1}{2}$ Points from the South West-wards; and A C two half Points from the South Eastward. *1 Course S. W. ½ W.* *2 Course S. S. E. ½ E.*

The Operation by the Logarithms.

As the Sum of their Departures C B 82 Leagues——1.91381

To the Difference of their Departure S B 32 Leagues——1.50515
So is the Sine of the Sum of their Courses C A B 78 deg. 45 min.——9.99157

To the Sine of the Difference of their Courses——11.49672

S A B 22 deg. 30 min.——9.58291

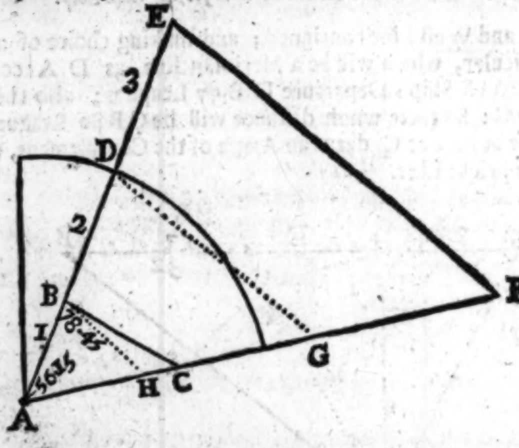
Now 22 deg. 30 min. added to 78 deg. 45 min. the half Sum is 50 deg. 37 min. and a half; that is 4 Points and a half or S. W. half W. for the one Ships Course sailed from A to B: and 22 deg. 30 min. subtracted from 78 deg. 45 min. the half Sum is 28 deg. 07 min. and a half, that is 2 Points and a half or S. S. E. half a Point Easterly, for the other Ship's Course.

Quest.

Quest. VI. *From the Port at* A, *I sail S. S. West unto* B, *and from* B, *I sail N. W. by W. unto* C; *and from* C, *I sailed unto my first Port at* A, *E. by N. Now having sailed in all* 120 *Leagues, I would know how many Leagues I have sailed upon each Point.*

First draw A B a South-South-West-line, then at a convenient distance, as from B, draw a North-West-by-West-Line, and from A draw the opposite Course of East by North, which is West by South, which will cut B C in C; so continue the Sides of the Triangle, as A B unto E, and A C unto F. Then lay B C from B unto D, and A C from D unto E. Then take 120 Leagues, and lay the same from A unto F: Next draw the Line E F, and from D and B draw Parallels thereunto, which will cut A F in G and H.

Lastly, measuring A H, you shall have $33\frac{2}{3}$ Leagues that you have sailed South South-West. And measuring H G, you shall have 39 Leagues $\frac{6}{10}$ parts that you have sailed North-West by West. Also measuring G F, you shall have $46\frac{1}{4}$ Leagues near, that you have sailed East by North, which makes in all near 120 Leagues.



Arithmetically, By the Table of Natural Sines in the Seaman's Kalendar.

First, Add up all the Sines of the Angles together,

deg.	min.	
45	00	Sine 7071
56	15	8315
78	45	9808
		25194

Then by the Rule of Three.

As 25194, to 120 Leagues : So $\left\{\begin{matrix}7071\\8315\\9808\end{matrix}\right\}$ To the Distance sailed $\left\{\begin{matrix}\text{S. S. W. } 33\frac{68}{100} \text{ A B.}\\ \text{N. W. b. W. } 39\frac{60}{100} \text{ Leagues.}\\ \text{E. b. N. } 46\frac{72}{100} \text{ C A.}\end{matrix}\right.$

CHAP. VII.

The Disagreement betwixt the ordinary Sea-Chart, and the Globe; and the agreement between the Globe and the true Chart, according to Mr. Wright's *Projection.*

THE Meridians in the ordinary Sea-Chart are Right Lines, all parallel one to another, and consequently do never meet; yet they cut the Æquinoctial, and all Circels of Latitude, at Right Angles, as in the Terrestrial Globe: But herein it differeth from the Globe, for that here all the Parallels to the Æquinoctial being lesser Circles, are made equal to the Æquinoctial it self, being a great Circle; and consequently the Degrees of those Parallels or lesser Circles, are equal to the Degrees of the Æquinoctial, or any other great Circle, which is meerly false, and contrary to the nature of the Globe.

The Meridians in the Terrestrial Globe do all meet in the Poles of the World, cutting the Æquinoctial, and consequently all Circles of Latitude, or Parallels to the Æquator at Right Angles. and all such Parallels do grow lesser towards either Pole, decreasing from the Æquinoctial Line. For Example, 360 Degrees, or the whole Circle in the Parallel

rallel of 60 deg. is but 180 deg. of the Æquinoctial; Whereas in the Plain Chart, that Parallel and all others are made equal one to another, and to the Æquinoctial Circle, as we have said before. The Meridians in a Chart of (*Mercator* or) *Wright's* Projection, are Right-Lines, all Parallel one to another, and cross the Æquinoctial, and all Circles of Latitude, at Right Angles, as in the ordinary Sea-Chart: But in this Chart, though the Circles of Latitude be all equal to the Æquinoctial and one to another, yet they keep the same proportion to the Meridian by reason of the inlarging thereof, as the same Parallels in the Globe do. Wherein it differeth from the ordinary Sea-Chart, for in that the degrees of great and lesser Circles are equal; and in this, though the degrees of the Circles of Latitude are equal, yet the degrees of the Meridian are unequal, being inlarged from the Æquinoctial towards either Pole, to retain the same Proportion as they do in the Globe it self; for as two degrees of the Parallel of 60 deg. is but one of the Equinoctial, or any great Circle upon the Globe, so here two degrees of the Æquinoctial, or of any Circle of Latitude is but equal to one degree of the Meridian, betwixt the Latitude of 59½ and 60½ deg. and so of the rest. Now for the making of this Table of Latitudes or Meridional Parts, it is by an addition of Secants; for the Parallels of Latitude are less than the Æquator or Meridian, in such proportion as the Radius is to the Secant of the Parallel. For Example. The Parallel of 67 deg. if less than the Æquator; and consequently each degree of this Parallel of 60 deg. less than a deg. of the Æquator or Meridian, in such proportion as 100000 Radius, hath to 200000 the Secant of 60 degrees.

Now to shew how *Gunter* and *Norwood*'s Tables are made, which was by the help of Mr. *Wright*'s Tables of Latitude. *Gunter*'s being an Abridgment, consisting of the Quotient of every sixth Number, divided by six, and two Figures cut off.

For Example. In *Wright*'s Tables of Latitude for 40 degrees the Number is 26227559.

That divided by 6, cutting off two Figures, the Quotient is 43 deg. 712 parts of the Æquator, to make 40 deg. of the Meridian.

And *Norwood*'s Tables of Meridional Parts, is an Abridgment of *Wright*'s Table of Latitudes; namely, every sixth Number cutting off four Figures to the right hand, as for 40 deg. as before the Number is 26.227559, from which cutting off four Figures, makes the Meridional parts 2623, as you will find by this Table.

So this Table sheweth how many parts every degree, and every tenth part of a degree of Latitude in this Chart, is from the Æquinoctial; namely, of such parts, as a degree of the Æquator containeth 60. And this which I here exhibit, and call a Table of Meridional Parts, is also an Abridgment of the Table of Latitudes of *Wright's*; namely, omitting always the three last Figures and dividing the residue by 3. For Example. The Numbers for 40 deg. are 26, 227, 559; omit the 3 last, and divide the rest by 3, and in the Quotient is 8742, the Meridional parts for 40 deg. and so of the rest: So that this Table sheweth how many parts every deg. and every tenth min. of Latitude is from the Æquinoctial in Leagues and Tenths.

The Use of this Table shall partly appear in the Problems following.

PROB. 1. *How to find by the following Tables what Meridional Parts are contained in any Difference of Latitude.*

IN the following Table you must take the Meridional Parts answering to each Latitude, and subtract the lesser from the greater; so the Remainder is the Number of Meridional Parts contained in the Difference of Latitude proposed; except the two Latitudes be one Northerly, and the other Southerly, then add the Meridional parts together, and that Sum is the Difference of Latitude in Meridional parts.

As, Let one Latitude be 51 deg. 20 min. N.——12002 } Meridional Parts.
And the other Latitude be 13 deg. 10 min. N.—— 2657 }

9345

The Meridional Parts contained in the Difference of Latitude, are $934\frac{5}{10}$ Leagues.

PROB. 2. *The Latitudes of two Places being given, and difference of Longitude of both Places; To find the Rhomb and Distance.*

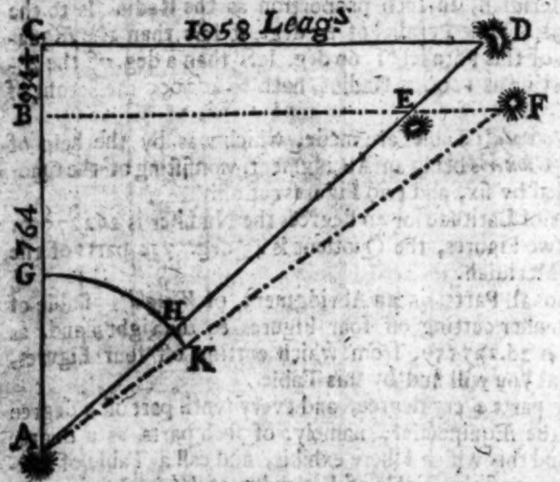
TO the intent the Application may be the more evident, our Example shall be of two Places before expressed in the Plain Chart.

Suppose the Latitude of the Island of *Lundy* in the Mouth of *Severn*, to be at A, 51 deg. 22 min. and the Latitude of *Barbadoes* 13 deg. 10. min. at B, and the Difference of Longitude 52 deg. 55 min. C D, that the *Barbadoes* is to the Westward of the Island of *Lundy*; The Course and Distance from the one Place to the other is demanded.

	Longitude d.	m.
Lundy	25	52
	360	00
	385	52
Barbadoes	332	57
Differ.	52	55
	20	
	1040	
	$18\frac{1}{3}$	
	1058	
	51 d.	22. m.
	13	10
	38	12
	20	
	760	
	4	
	764	

First you may demonstrate the Question by the Scale.

Draw the Right Line A C for the Meridian; and in regard the difference of Latitude is 38 deg. 12 min. convert them into Leagues, by multiplying them by 20, and the odd minutes divide by 3, and the difference in Leagues will be 764; which lay from A to B, for the common difference of Latitude.



Then take the Difference of the two Latitudes inlarged, $934\frac{1}{3}$ Leagues, and lay from A to C; then draw the two Parallel Lines, as B E and C D. Then 52 deg. 55 min. the Difference of Longitude, converted into Leagues, (as before directed) is $1058\frac{1}{3}$, which lay from C to D, and draw the Line A D, which is the true Course from A to D, and A E is the true Distance. And as D is the Point representing *Barbadoes* by *Mercator's* Chart, so is E the Point representing the same Place by the *Plain Chart*. And as C D is the Longitude by the Globe, so is B E the Meridian Distance between *Lundy* and *Barbadoes*. You will find the true Course S. W. a little more than a quarter Westerly, and the Distance is 1154 Leagues. Now by the *Plain Sea-Chart* the Course is B A F, S. W. above three quarters of a Point Westerly; and the Distance is A F 1306 Leagues: So that the *Plain Chart* sheweth the Distance more than it is by 152 Leagues, and the Course more Westerly by half a Point, which is a gross Error; and so grosly are those Men mistaken that use a *Plain Chart*.

To find the Course and Distance by the Logarithms.

Admit a Ship is at A, in Latitude 51 deg. 22 min. North at *Lundy*, and is to sail to D in Latitude 13 deg. 10 min. which is *Barbadoes*; and the Difference of Longitude is 1058 Leagues.

First find the Difference of Latitude inlarged, as is before directed in the first Problem, and was found to be $934\frac{1}{3}$ Leagues.

Now you have given A C the Difference of Latitude inlarged, and C D the Difference of Longitude 52 deg. 55 min. whereby the Angles and Hypothenusal shall be found by the Resolution of a Right-angled Triangle.

Therefore

A Table of the Meridonal Parts to the tenth part of a League, and for every 10 Minutes of Latitude from the Equinoctial.

Minutes.	DEGREES. 0	1	2	3	4	5	6	7	8	9	Minutes.
	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	l. 1/10	
00	00	200	400	600	801	1001	1202	1403	1605	1807	00
10	33	233	433	634	834	1035	1236	1437	1639	1841	10
20	67	267	467	667	867	1068	1269	1471	1673	1875	20
30	100	300	500	700	901	1102	1303	1504	1706	1909	30
40	133	333	534	734	934	1135	1336	1538	1740	1943	40
50	167	367	567	767	968	1109	1370	1571	1774	1976	50
M	10	11	12	13	14	15	16	17	18	19	M
00	2010	2214	2418	2623	2828	3035	3242	3451	3661	3827	00
10	2044	2248	2452	2657	2863	3069	3277	3486	3696	3907	10
20	2078	2282	2486	2691	2897	3104	3312	3521	3731	3942	20
30	2112	2316	2520	2725	2931	3138	3347	3556	3766	3977	30
40	2164	2350	2554	2760	2966	3175	3381	3591	3801	4013	40
50	2180	2384	2588	2794	3000	3208	3416	3626	3836	4048	50
M	20	21	22	23	24	25	26	27	28	29	M
00	4084	4297	4512	4729	4947	5167	5388	5612	5837	6065	00
10	4119	4333	4548	4765	4983	5203	5425	5648	5875	6103	10
20	4155	4369	4584	4801	5020	5240	5462	5686	5913	6141	20
30	4196	4405	4620	4838	5056	5277	5500	5724	5951	6179	30
40	4216	4440	4656	4874	5090	5314	5537	5761	5989	6218	40
50	4262	4476	4692	4910	5130	5351	5574	5799	6027	6256	50
M	30	31	32	33	34	35	36	37	38	39	M
00	6294	6527	6761	6998	7238	7481	7726	7975	8217	8483	00
10	6333	6565	6800	7038	7278	7521	7768	8017	[illegible]	[illegible]	10
20	6371	6604	6840	7078	7319	7562	7809	8059	8312	8569	20
30	6410	6644	6879	7118	7359	7603	7850	8101	8355	[illegible]	30
40	6449	6683	6919	7158	7400	7644	7892	8143	8397	8655	40
50	6488	6722	6938	7198	7440	7685	7934	8185	8440	8699	50
M	40	41	42	43	44	45	46	47	48	49	M
00	8742	9005	9272	9543	9819	10100	10285	10675	10971	11273	00
10	8786	9049	9317	9589	9865	10147	10433	10724	11021	11324	10
20	8829	9093	9362	9635	9912	10194	10481	10773	12074	11375	20
30	8873	9138	9407	9681	9959	10241	10530	10823	11125	11426	30
40	8917	9182	9452	9727	10005	10289	10578	10872	11174	11478	40
50	9961	9227	9498	9773	10052	10337	10626	10922	11222	11529	50
M	50	51	52	53	54	55	56	57	58	59	M
00	11581	11896	12217	12545	12881	13226	13581	13941	14313	14696	00
10	11633	11949	12271	12600	12938	13284	13640	14004	14377	14761	10
20	11685	12002	12325	12656	12995	13342	13700	14063	14440	14826	20
30	11737	12055	12380	12712	13052	13401	13759	14121	14504	14892	30
40	11790	12109	12435	12768	13110	13460	13820	14188	14568	14958	40
50	11842	12163	12490	12825	13168	13520	13881	14251	14632	15024	50
M	60	61	62	63	64	65	66	67	68	69	M
00	15091	15497	15917	16350	16798	17263	17745	18246	18769	19315	00
10	15158	15586	15988	16423	16874	17342	17827	18331	18858	19408	10
20	15225	15635	16059	16497	16951	17421	17910	18418	18948	19502	20
30	15293	15705	16131	16572	17028	17501	17993	18505	19035	19597	30
40	15300	15775	16204	16647	17106	17582	18077	18592	[illegible]	19693	40
50	15428	15848	16277	16721	16184	17662	18161	18680	19222	19784	50
M	70	71	72	73	74	75	76	77	78	79	M
00	19886	20485	21116	21781	22485	23234	24033	24890	25815	26819	00
10	19984	20588	21224	21896	22607	23368	24172	25039	25976	26995	10
20	20083	20692	21333	22011	22730	23495	24312	25190	26140	27173	20
30	20183	20796	21444	22128	22854	23628	24455	25344	26306	27354	30
40	20283	20901	21555	22246	23979	23761	24598	25499	26474	27530	40
50	20384	21008	21668	22364	23106	23897	24743	25656	26645	27727	50
M	80	81	82	83	84	85	86	87	88	89	M
00	27917	29130	30484	32019	33789	35881	[illegible]	40740	[illegible]	[illegible]	00
10	28110	29345	30726	32296	34112	36170	38329	42395	47385	56420	10
20	28307	29564	30974	32579	34445	36673	39439	43090	48677	58977	20
30	28507	29787	31226	32870	34788	37096	39973	43830	49684	62274	30
40	28711	30015	31484	33168	35141	37523	40532	44621	51034	66920	40
50	28919	30247	31748	33474	35595	37973	41120	45979	52504	74863	50

Therefore for the Course.

As the Difference of Latitude inlarged A C is 934$\frac{5}{11}$ parts——2.97057
Is in Proportion to the Radius 90 deg.——10.00000
So is the Difference of Longitude in such Parts C D 1058$\frac{1}{5}$——3.02448

To the Tangent of the Rhomb, the Angle at A 48 deg. 33 min.——10.05391

Extend the Compasses from 934$\frac{5}{11}$ Leagues, the inlarged Latitude, to 1058$\frac{1}{5}$ Leagues; the same distance will reach from the Radius to the Tangent of the Course 48 deg. 33 min. which is the Course from *Lundy* to *Barbadoes*, S. W. a little above a quarter of a Point Westerly.

For the Distance.

As the Sine-Complement of the Rhomb, the Angle at D 41 d. 27 m.——9.82083
To the Difference of Latitude A B 764 Leagues——2.88309
So is the Radius——10.00000
To the Distance A E 1154$\frac{2}{11}$ Leagues——3.06226

Extend the Compasses from the Complement-Sine of the Rhomb 41 deg. 27 min. to the Sine of 90 deg. the same Extent will reach from the difference of Latitude 764 Leagues, to the distance A E 1154 Leagues, which is required.

PROB. 3. *The Latitude of two Places, and their distance given; To find the Course and the difference of Longitude.*

ADmit I sail from the Island of *Lundy*, in the Latitude 51 deg. 22 min. in the South-west Quarter of the Compass, 1154$\frac{2}{11}$ Leagues; and then find my self in the Latitude of 13 deg. 10 min. I would know upon what Point of the Compass I have failed, and my difference of Longitude to the Westward.

The diff. of Lat. A B is 38 deg. 12 min. which reduced into Leagues is 764 Leagues.

For the Course.

As the distance sailed 1154$\frac{2}{11}$ Leagues AE——3.06228
Is in proportion to the Radius, 90 deg.——10.00000
So is the true Difference of the Latitude 764 Leagues A B——2.88309

To the Sine-Compl. of the Rhomb 41 deg. 27 min. the Angle at D——9.82081

That is S. W. $\frac{1}{4}$ W. or S. W. 3 deg. 33 min. Westerly, the Course that the Ship hath sailed upon.

Extend the Compasses from 1154 Leagues the distance to the Sine of 90; the same distance will reach from the difference of Latitude 764 Leagues, to 41 deg. 27 min. the Co-sine of the Rhomb: The Rhomb is 48 deg. 33 min. that is, 4 Points and above a quarter from the South-westward from the Meridian.

Secondly, For the difference of Longitude.

Find by the first Problem the difference of Latitude inlarged, 934$\frac{5}{11}$ Leagues.

Then as the Radius——10.00000
To the Diff. Lat. in Merid. parts 934$\frac{5}{11}$ A C——2.97057 *Inlarged.*
So is the Tangent of the Rhomb 48 deg. 33 min A——10.05395

To the difference of Longitude in parts 1058 Leagues——3.02452

Extend the Compasses from the Tang. 45 deg. to the difference of the Latitude inlarged 934$\frac{5}{11}$ Leagues; the same extent will reach from the Tangent of the Course 48 d. 33 m. to 1058 Leagues. 1058 Leagues converted into Degrees, by dividing by 20, the Quotient is 52 deg. 54 min. the difference of Longitude required.

PROB. 4.

PROB. 4. *By the difference of Longitude, one Latitude and the Course, to find the other Latitude and distance run.*

SUppose I sail from *Lundy*, in Lat. 51 deg. 22 min. North. S. W. 3 deg. 33 min. Westerly, or S. 48 deg. 33 min. Westerly, until my difference of Longitude be 52 d. 55 m. I demand how much I have laid the Pole, and how far I am from *Lundy?*

For the difference of Latitude.

As the Tangent of the Rhomb 48 deg. 33 min.——————10.05305
To the difference of Longitude C D 1058 Leagues——————3.02448
So is the Radius——————10.00000

To the difference of Lat. in Merid. parts Leag. 933$\frac{4}{10}$ A C——————2.97053

By the Artificial Lines on the Scale.

Extend the Compasses from Tangent 48 deg. 33 min. to 1058 in the Line of Numbers; the same extent will reach from Tangent 45 deg. to 934$\frac{4}{10}$ Leagues.

Or, extend the Compasses from Tang. 48 deg. 33 min. to Tang. 45 deg. the same distance will reach from 1058 Leagues, to A C 934$\frac{4}{10}$ Leagues, as before.

Now the Meridian parts answering the Latitude of 51 deg. 20 min. are 12002; from it subtract 9344 here found, and there remains 2658, which Number I look for in the Table, and find the nearest, *viz.* 2657 under 13 deg. and 10 min. which is the Latitude of the second Place where the Ship is; and the difference of Latitude is 38 deg. 12 min. The distance may be found as before, in the second Problem.

$$\begin{array}{r} 12002 \\ 9344 \\ \hline 2658 \end{array}$$

PROB. 5. *By the Course and Distance, and one Latitude; to find the other Latitude, and difference of Longitude.*

SUppose I sail S. W. 3 deg. 33 min. Westerly, or South 48 deg. 33. min. Westerly, 1157 Leagues, and by Observation find my self in the Latitude of 13 deg. 10 min. I require the Latitude of the Place from whence I came, and the difference of Longitude between the two Places.

For the Difference of Latitude.

As the Radius——————10.00000

To the distance sailed 1154 Leagues A E——————3.06220
So is the Sine-Complement of the Course E, 41 deg. 27 min.——————9.82083

To the difference of Latitude 763$\frac{8}{10}$ or 964 Leagues——————2.88303

Extend the Compasses from the Sine of 90 deg. to 1154 Leagues; the same will reach from the Sine of 41 deg. 27 min. to 764 Leagues; 764 Leagues is 38 deg. 12 min. the difference of Latitude; which added to 13 deg. 10 min. the Latitude of the last Place, the Total is 51 deg. 22 min. the Latitude of the first Place required.

The difference of Longitude is found as before in the third Problem, saying;
As the Radius, to the difference Latitude; inlarged 934$\frac{4}{10}$.
So is the Tangent of 48 deg. 33 min. to the difference of Longitude in Leagues 1058, which is 52 deg 55 min.

Now to convert the difference of Longitude found in any Latitude into Leagues of Departure or Distance, do it after the Example following.

Suppose two Places in one parallel of Latitude, as in the parallel of 51 deg. 22 min. whose difference of Longitude is 52 deg. 55 min. I require the distance of those two Places.

As the Radius——————10.00000
Is to the Compl. Sine of the Latitude 51 deg. 22 min.——————9.79542
So is the difference of Longitude 1058 *Leagues*——————3.02448
To the distance in that *Latitude* 660 *Leagues* $\frac{6}{10}$——————2.81990

CHAP. VIII.

How to divide a particular Sea-Chart according to Wright's *Projection, commonly called* Mercator's *Chart.*

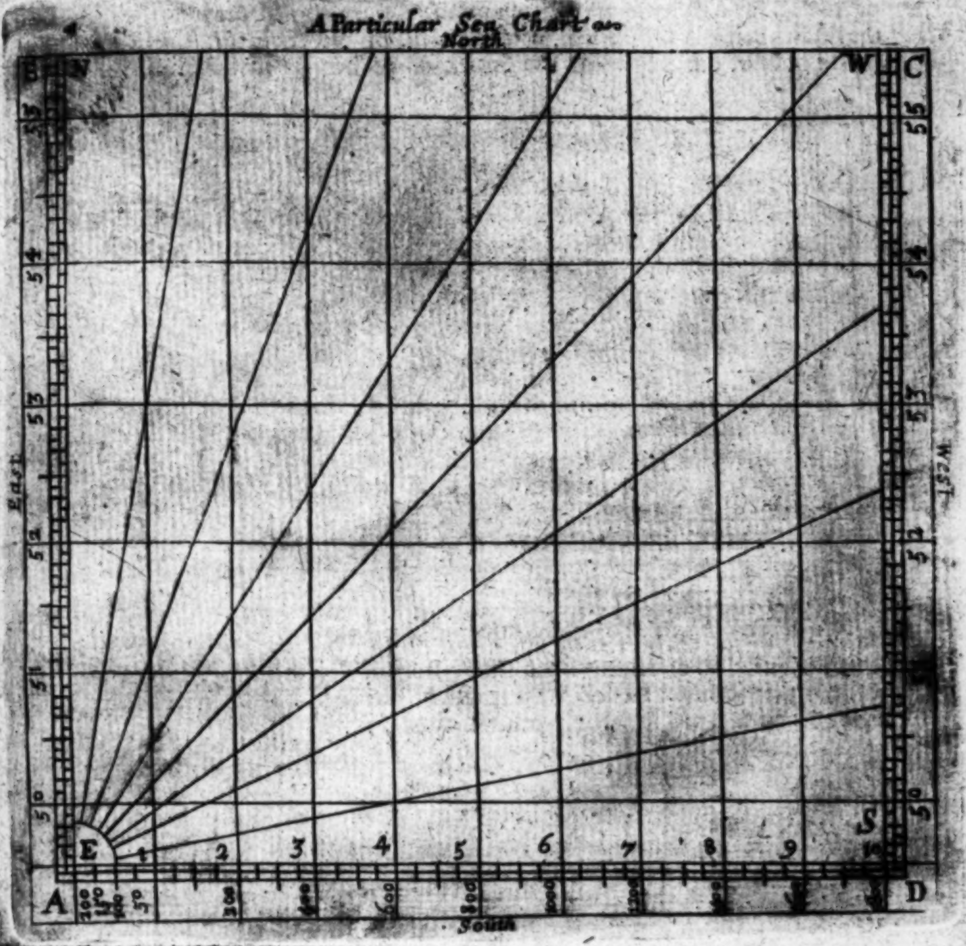
IF it be a particular Chart you would make, you must first consider the two Latitudes you would make your Chart for; and out of the foregoing Table of Meridional parts, take the Numbers answering to each Latit. and subtract the lesser out of the greater, and the remainder is the Number which you must take for the extream parallels of Latitude.

55 : 30
49
13401
11426
49
1975
x
x975(9:52
20

Deg.	Min.	Parts. Merid.	Differ.	Equal Parts.
	30	13401		1957
	20	13342	59	1916
	10	13284	58	1858
55	00	13226	58	1800
	50	13168	58	1742
	40	13110	58	1684
	30	13052	58	1626
	20	12955	57	1569
	10	12938	57	1512
54	00	12881	57	1455
	50	12825	56	1399
	40	12768	57	1342
	30	12712	56	1286
	20	12656	56	1230
	10	12600	56	1174
53	00	12545	55	1119
	50	12490	55	1064
	40	12435	55	1009
	30	12380	55	954
	20	12325	55	899
	10	12271	54	845
52	00	12217	54	791
	50	12163	54	737
	40	12109	54	683
	30	12055	54	629
	20	12002	53	576
	10	11949	53	523
51	00	11896	53	470
	50	11842	54	416
	40	11790	52	364
	30	11737	53	311
	20	11685	52	259
	10	11633	52	207
50	00	11581	52	155
	50	11529	52	103
	40	11478	51	52
	30	11426	52	

Example. I would make a Blank *Mercator's* Chart, from the Latitude of 49 deg. 30 min. to 55 deg. 30 min. and for 10 deg. of Longitude. Look in the Table of Meridional parts, and for the Latitude of 49 deg. 30 min. you will find the Number answering thereunto is 11426, and for the *Latitude* of 55 deg. 30 min. is 13401, the least subtracted from the greater, the remainder is 197,5 equal parts for the length of the *Meridian-Line.* Therefore first draw the *Line* A B for the *Meridian-Line*, and cross it with two Perpendiculars, as BC and A D: then divide one of the Parallels of *Latitude*, into 10 equal parts, as A D, and subdivide each of those deg. into 20 equal parts or *Leagues*, and suppose each of these 20 parts to be divided into 10 parts more, so will a deg. be divided into 200 parts: Then take with your Compasses 197,5 equal parts out of the *Line* A D, and lay from A to B, and from D to C, for the extream parallels of *Latitude*; and through each deg. of *Longitude* marked with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; draw *Meridian-Lines* parallel to the the first *Meridian*: Then out of the Table of *Meridional parts* collect the Numbers answering to every 10 min. of *Latitude*, as in this Table annexed, which subtracted the lesser from the greater, the remain is the difference, as in the third Column: Then add the *Difference* together, which maketh the Number in the fourth Column in this manner; 52 for the first 10 min. and 51 min. added to it, make 103 for 50 min. and 52 added to 103 makes 154 for the Number of equal parts you must take out of the *Line* A D for 30 min. from A to 50 deg. of *Latitude*, and lay it on both sides of the Chart, and draw the parallel of 50 deg. of *Latitude*: And so do of the rest, as you see in this Table. So for 51 deg. the Number is 470; take 470 and lay it upwards from A to 51 deg. on both sides, and draw the parallels of 51 deg. of *Latitude*; and so do with the rest.

CHAP.



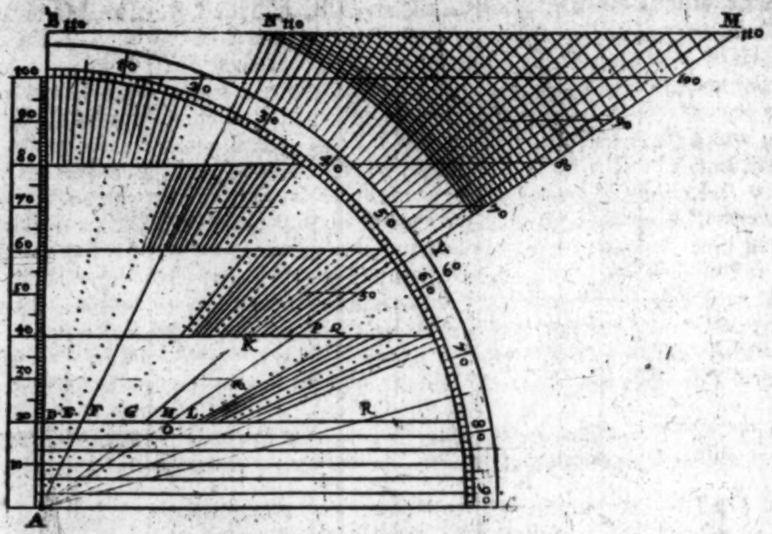
CHAP. IX. *The Projection of the Meridian-Line by Geometry, and how to make a Scale of Leagues for to measure Distances in any Latitude.*

THe Projection is the ground-work of *Wright's* Tables of *Latitudes*, in his *Correction of Errors in Navigation*, where he sheweth how to make it, and hath also made a Table by the continual addition of the Secants of every Minute, which shews how much you are to lengthen the deg. of *Latitude* in your *Chart*, that so there may be a true proportion between the *degrees* of *Longitude* and *Latitude* in all Places. Which Table I have abridged, by reducing into *Leagues* and tenth parts, as hath been shewed before. We will here shew you how to do the same by Geometry; that is, how to make a *Meridian-Line* answerable to any *Line* of *Longitudes*, and also to make a Scale of 100 *Leagues* to measure a distance in any *Latitude*. First, Make the Quadrant A B C, of what largeness you please, and divide the Limb thereof into 90 deg. and number them from B towards C; then divide the Side of the Quadrant into 5 equal parts, which are 5 deg. of the Equinoctial. Then divide the first deg. from the Center, as A D, into 6 equal parts, and through them draw parallel lines to A C: You may divide each of the other four deg. from D to B into 20 equal parts, which are Leagues, and so you may number them as you see, from 10 to 100: So the whole line A B will be your Radius, and the length of 110 *Leagues*, or 5 deg. and a half of *Longitude* of your *Chart*.

And because the *Degrees* of *Longitude* are to be of one length in all *Latitudes*, therefore the *degrees* of *Latitude* must increase as the *Secants* of the *Latitudes* increase.

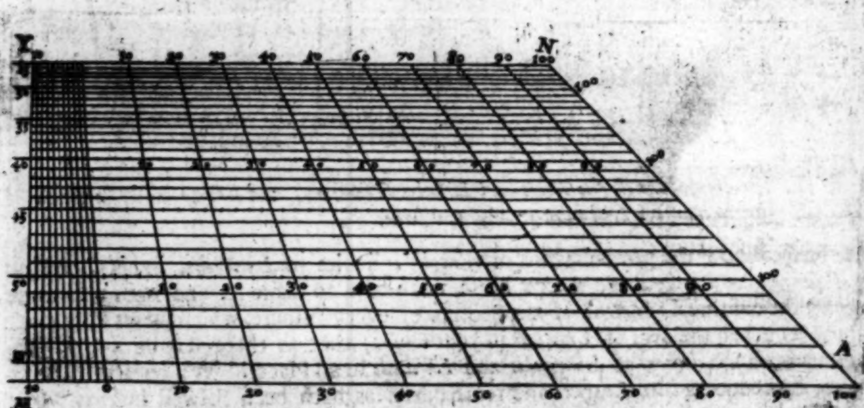
There-

Therefore if you would know how long one *degree* of *Latitude* must be in the *Latitude* of 50 deg. lay a Ruler on 50 deg. and on the Center A, and draw the Line A H. Now the Radius being A D, the length of one deg. of the Æquator, this Line A h, or h K (being both of one length) is the Secant of 50 deg. to that Radius, and must be the



length of one deg. of Latitude in a Chart from 50 deg. to 51 deg. and so the Line A E which is the Secant of 20 deg. is the length of one deg. of the Meridian-line in the Latitude of 20 deg. and so for any other Latitude.

A Scale of Leagues from the Lat. of 25 deg. to the Lat. of 56 deg.



How to make the Scale of Leagues

THe Quadrant being drawn as before directed, take 110 Leagues and lay from A to B, and draw the Line M N B at Right Angles thereunto: and if it be for a particular Chart, as that before going, draw Lines from the Center through every degree of Latitude; as you see in the Quadrant I have done. So if you would know the length of 100 Leagues in the Latitude of 25 deg. lay a Ruler upon 25 deg. in the Arch of the Quadrant and the Center, and draw the Line A N, and that is the length of 110 Leagues in that Latitude: So if you draw Parallel-lines to M N through every 10 Leagues in the Side A B, you will have the length of every 10 Leagues in any deg. of Latitude, as you may plainly see in the Quadrant; and so you may do for every League if you please. Suppose you would know the length of 40 Leagues in the Latitude 50 deg. extend the

Compasses

Compasses from A to K, and that distance is 40 Leagues in that Latitude: And in like manner work by the rest in any other Latitude. If you would make this into a Scale, as the Figure Y M m N; first in the Quadrant extend your Compasses from the Center A, to the Intersections of the Line drawn through every deg. and lay them down upon the side of the Scale, from Y towards M, from the Lat. of 25 d. to the Lat. of 56 d. and this is the Meridian-line of your Scale, then draw the Parallel-lines Y N and M m for the extream Parallels of your Scale; and draw Parallel-lines to all these deg. as you see: then extend the Compasses from the Cent. of the Quad. to M, for the length of the lowermost Line of your Scale M m 110 Leagues, and extend the Compasses from the Cent. of the Quadrant to N, which the length of 110 Leagues in the Lat. of 25 deg. and it is the length of the uppermost Line Y N of your Scale; and draw N m the out-side Line of your Scale: So take every 10 Leagues from the Center A, in the Line A M, in Lat. 56 deg. and divide the lowermost Line of the Scale; and the like do in the Lat. of 25, for to divide the uppermost Line of the Scale; and draw Lines through each of them, which will divide all the rest of the Parallel-lines in each Latitude into 10 Leagues and number them as you see in the Scale; and divide the first 10 Leagues next the Meridian-line of the Scale into 10 equal parts below and above, and draw Lines through each of the Divisions: So have you divided your Scale to every deg. of Latitude into Leagues; which will measure the distance of any two places in the true Chart, which are near the same Parallel of Latitude.

Thus far the Author. I shall next incert the 14 *following Problems in* Mercators's *Sailing, by Mr.* John Colson, *being a new Addition of his to the* Mariner's Kalendar.

PROB. I. TWO Places in the same Parallel of Latitude, the Difference of Longitude between them given, to find the Distance of those Places in the Parallel.

Example. *Cape* St. *Vincent*, and the S. Point of St. *Mary's*, both in the Lat. 37° 0′ N. the Difference of Longitude between them 16° 40′ (or 1000 min.) to find the Distance.

In the annexed Scheme, P represents the North Pole, E Q an Arch of the Equinoctial, M St. *Mary's*, V *Cape* St. *Vincent*, P M E the Meridian of St. *Mary's*, P V Q the Meridian of *Cape* St. *Vincent*, the Angle MPV, or the Arch E Q, the Difference of Longitude between St. *Mary's* and Cape St. *Vincent*, M V the Distance between them in the Parallel of Latitude.

The Operation by the Logarithms.

As Radius	10.0000000
To the Difference of Longitude 1000 min.	3.0000000
So is the Sine Comp. of the Lat. 37° 00′	9.9023486
To the Distance between them 798 min.	12.9023486

PROB. II. Two Places both in the same Latitude, the Distance (in the Parallel) between them given, to find the Difference of Longitude.

Examp. *Cape* St. *Vincent*, and the S. Point of St. *Mary's*, both in the Latitude of 37° 0′ N. the Distance between them 799 min. to find the Difference of Longitude.

The Operation by the Logarithms.

As the Sine Comp. of the Lat. 37° 0′	9.9023486
To the Distance 799 min.	2.9025468
So is Radius	10.0000000
To the Difference of Longitude 1000 min.	3.0001982

PROB. III. The Difference of Longitude and Distance between two Places, both in the same Latitude; to find the Latitude.

Examp. The Difference of Longitude between *Cape* St. *Vincent*, and the S. Point of St. *Mary's*, being in the same Latitude, is 16° 40′, and the Distance 799 min. to find the Latitude of those Places.

The Operation by the Logarithms.

As the Difference of Longitude 1000 min.	3.0000000
To Radius	10.0000000
So is the Distance 799 min.	2.9025468
To the Sine Comp. of the Lat. 36° 58′	9.9025468

The Reason, why the Latitude of the two Places found by this Operation, differs from the Latitude given in the first Problem, is because the Distance found by that Problem is 798 min. $\frac{6}{10}$; but in the third Problem we take the Distance 799 min. being unwilling to trouble the Learner with Fractions.

PROB. IV. To find the Meridional Difference of Latitude between any two Places, by the Table of the Logarithmical Tangents.

How it was first discover'd is uncertain, but it was first published by Mr. *Henry Bond*, in the Second Edition of *Gunter*'s Works 1636; and afterwards by the same Author, in the First Edition of *Norwood*'s Epitomy 1645, that the Logarithmical Tang. Complements of half the Comp. of the Latitude, are proportional to the Sum of the Secants, or the Meridian Line in *Mercator*'s Chart, (commonly so called) altho 'tis certain 'twas Mr. *Wright*'s Invention, (and ought to bear his Name) as he has made it appear in the Preface of his Book; the *Correction of Errors in Navigation*, first Published 1599. This Analogy was afterwards demonstrated by the Learned Mr. *James Gregory*, in his *Exercitationes Geometricæ* 1668, and very lately by Mr. *Edmond Halley*, who according to his happy Genius, hath very clearly and succinctly demonstrated in the Philosophical Transactions N° 219, published 1696, that the Logarithmick Tangents, are Analogous to the Meridian Line, and that as the Meridian Line is a Table of the Difference of Longitude to every minute of Latitude on the 4th Rhomb from the *Meridian*; so the Logarithmick Tangents are a Table of the Difference of Longitude, to every minute of Latitude to some determinate Rhomb. And as the Tangent of that Rhomb, to the Tangent of any other Rhomb; so is the Difference of the Logarithms of any two Tangents, to the Difference of Longitude on the proposed Rhomb, intercepted between the two Latitudes of whose half Complement you took the Tangent or Tangent Complement. The Meridional Difference of Latitude for 1 min. of Lat. from the Equinoctial, in the Scale of Logarithmick-Tangents (by the common Tables) is 1263, and in *Vlacq*'s *Canon Magnus* 1263311.

Therefore as 1263, to 1 min. so is the Difference of any two Logarithmick Tangents to the Meridian Difference of Latitude in Minutes, between those two Arches in the Quadrant, of whose half Complements the Tangents or Tangent-Complements were taken. And as 1 min. to Radius, so is 1.263, to the Tangent of 51° 38′; the Angle that Rhomb makes with the Meridian, on which the Scale of *Brigg*'s Logarithm-Tangents, are a Table of the Diff. of Long. Or as 1 min. to Radius; so is 1.263311, to the Tangent 51° 38′ 9″, as Mr *Halley* has determined it.

1. If the two Places be both in North and South Latitude, divide the Difference of the Logarithmical Tangents, or Tangent-Complements, of half the Compl. of the Latitude to 90 degrees, by 1263, the Quotient in the meridional Difference of Latitude in minutes.

Examp. Suppose two places, one in the Lat. 50° 10′, the other in the Lat. 37° 54′ (both North or South Latitude) to find the meridional Difference of Latitude between them.

Lat. 50° 10′, Comp. 39° 50′, ½ Comp. 19° 55′,
Lat. 37° 54′, Comp. 52° 06′, ½ Comp. 26° 03′,

The Log. T. of 19° 55′	9.5590971	T. C. of 19° 55′	10.4409029
The Log. T. of 26° 03′	9.6891430	T. C. of 26° 03′	10.3108570
The Diff.	1300459	The Diff.	1300459

1263) 1300459 (1029 the Merid. Diff. of Latitude in Minutes.

2. If one Place be under the Equinoctial, and the other in the North or South Lat.

Divide

Divide the Difference of the Log. Tangents, or Tang. Complements of half the Complement of the Latitude, and of the Tangents of 45 deg. by 1263, the Quotient is the Meridional Difference of Latitude in minutes.

Examp. One place under the Equinoctial, and the other in the Lat. 50° 10′, to find the meridional Difference of Latitude.

The Log. T. of 19° 55′	9.5590971	T. C. of 19° 55′	10.4409029
The Log. T. of 45° 00′	10.0000000	T of 45° 00′	10.0000000
The Diff.	4409029	The Diff.	4409029

1263) 4409029 (3490 the Merid. Diff. of Latitude in minutes.

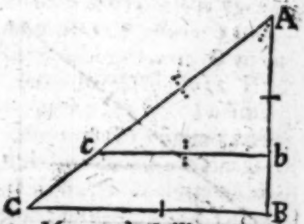
3. If one Place be in North, and the other in South Latitude. Divide the Sum of the two Differences of the Tang. of 45 deg. and the Tangents or Tang. Complements of half the Comp. of the two Latitudes, by 1263; the Quotient is the meridional Difference of Latitude.

Examp. Suppose one place in the Lat. 50° 0′ N. the other in the Lat. 32° 20′ S. to find the meridional Difference of Latitude in minutes.

The Difference of the Tang. of 45°, and the Tang. or Tang. Comp. of 20° 0′, is 4389341, the Difference of the Tang. of 45°, and the Tang. or Tang. Comp. of 28° 50′, is 2592328, the Sum of these two Differences, 6981669; divided by 1263, the Quotient 5527 is the Meridional Difference of Latitude in min.

PROB. V. Both Latitudes, and the Difference of Longitude given, to find the Course, the Distance and the Departure.

Examp. The *Lizard* in the Lat. 50° 10′ N. and the East-end of St. *Michael's*, in the Latitude of 37° 54′ N. the Difference of Long. between them 22 deg. or 1320 min. to find the Course from the *Lizard*, to St. *Michael's*, the Distance and Departure between them.



In the two Triangles A b c and A B C.

A c represents the Distance sailed, A b the Difference of Latitude, b c the Departure from the Meridian (as in Plain Sailing) A B the Meridional Difference of Latitude, B C the Difference of Longitude, according to *Mercator's* Sailing, B A C the Course, A c b or A C B the Complement of the Course.

The Difference of Latitude in Meridional Parts, found by the 4*th* Problem, is 1029 minutes.

The Operation by the Logarithms, to find the Course.

As the meridional Difference of Latitude 1029 min.	3.0124154
To Radius	10.0000000
So is the Difference of Longitude 1320 min.	3.1205739
To the Tang. of the Course 52° 03′	10.1081585

The Course is S. 52° 03′ W. or S. W. almost ½ W.

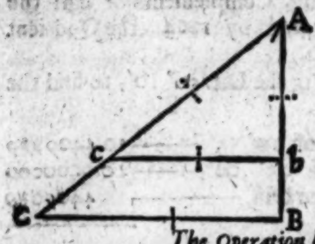
To find the Distance sailed.

As Radius	10.0000000
To the Difference of Latitude 736 min.	2.8668778
So is the Secant of the Course 52° 03′	10.2111435
To the Distance sailed 1197 min.	13.0780213

To find the Departure from the Meridian.

As Radius	10.0000000
To the Difference of Latitude 736 min.	2.8668778
So is the Tang. of the Course 52° 03′	10.1079715
To the Departure from the Meridian 943 min.	12.9748493

PROB.



PROB. VI. One Latitude, the Courſe and Difference of Longitude given, to find the other Latitude, the Diſtance and the Departure.

Examp. The *Lizard* in the Lat. 50° 10′ N. the Courſe from thence S. 52° 03′ W. and the Difference of Longitude 22°, to find the Latitude of the other place, the Diſtance and the Departure between them.

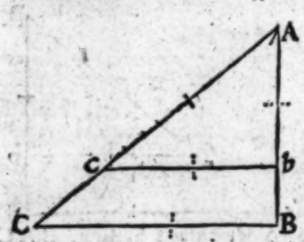
The Operation by the Logarithms, to find the other Latitude.

As the Tang. of the Courſe 52° 03′	10.1079715
To the Difference of Longitude 1320 min.	3.1205739
So is Radius	10.0000000
To the meridian Difference of Lat. 1029 min.	3.0126024

Multiply 1029 by 1263, the Product 1299627, ſubſtract from 10.4409029 the Tang. Comp. 19° 55′ (the half Comp. of 50° 10′,) the Remainder 10.3109402 is the Tang. Comp. of 26° 03′, the double whereof 52° 06′, ſubſtracted from 90 deg. leaves the Latitude of the 2*d* place 37° 54′ N.

Having both Latitudes and the Courſe, find the Diſtance and the Departure, as in the 5*th* Problem.

PROB. VII.



One Latitude, the Courſe and Diſtance given, to find the other Latitude, the Departure and the Difference of Longitude.

Examp. The Courſe from the *Lizard* in the Lat. 50° 10′ N. is S. 52° 03′ W. the Diſtance ſailed 1197 min. to find the other Lat. the Dep. and the Diff. of Longitude.

The Operation by the Logarithms, to find the other Latitude.

As Radius	10.0000000
To the Diſtance ſailed 1197 min.	3.0780941
So is the Sine Comp. of the Courſe 52° 03′	9.7888565
To the Difference of Latitude 736 min.	x2.8669506

To find the Departure.

As Radius	10.0000000
To the Diſtance ſailed 1197 min.	3.0780941
So is the Sine of the Courſe 52° 03′	9.8968280
To the Departure from the meridian 943 min.	x2.9749221

The Difference of Lat. 736 min. reduced into degrees and minutes, (dividing by 60) makes 12° 16′, which ſubſtracted from the 50° 10′ N. the Latitude of the *Lizard*, gives 37° 54′ N. the other Latitude. By the two Latitudes, find the meridian Diff. of Latitude by the 4*th* Problem.

To find the Difference of Longitude.

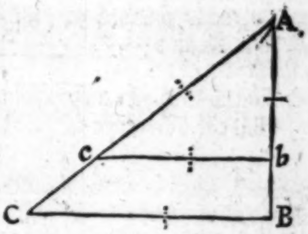
As Radius	10.0000000
To the meridional Difference of Latitude 1029 min.	3.0124154
So is the Tang. of the Courſe 52° 03′	10.1079715
To the Difference of Longitude 1319 min.	x3.1203869

The

The Meridional Difference of Latitude in the Scale of Logarithmick Tangents, (omitting the 3 last Figures) is 1300, and the Angle that Rhomb makes with the meridian, on which the Logarithmick Tangents become a Table of Diff. of Longitude, is 51°, 38′: from hence arises another Proportion to find the Diff. of Longitude.

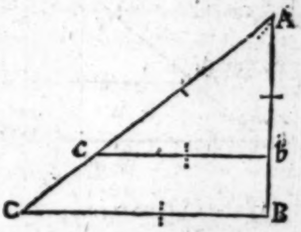
	Co. Ar.
As the Tangent of this Logarithmick Rhomb 51 deg. 38. min.	9.8985296
To the Meridional diff. of Lat. in the Logarithmick Scale 1300	3.1139433
So the Tangent of the given Rhomb or Course 52 deg. 03 min.	10.1079715
To the Difference of Longitude required 1319 min.	x3.1204444

PROB. VIII. Both Latitudes, and the Course given, to find the Distance, the Departure and the difference of Longitude.



Examp. From the *Lizard*, in the Lat. 50 deg. 10 min. N. to the East end of St. *Michael's*, the Course is S. 52 deg. 03 min. W. to find the Distance, the Departure and Difference of Longitude. Having both Latitude and the Course, find the Distance and the Departure by the 5th Problem, and the difference of Longitude by the 7th Problem.

PROB. IX. Both *Latitudes* and the distance given, to find the Course, the Departure and the Difference of Longitude.



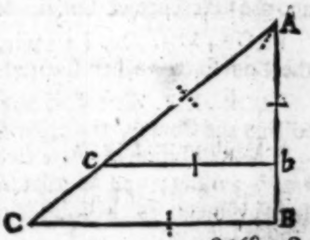
Examp. The distance between the *Lizard*, in the Lat. 50 deg. 10 min. N. and the East end of St. *Michael's*, in the Lat. 37 deg. 54 min. N. is 1197 min. to find the Course, the Departure and the difference of Longitude.

The Operation by the Logarithms. To find the Course.

As the difference of Latitude 736 min.	2.8668778
To Radius	10.0000000
So is the distance sailed 1197 min.	3.0780941
To the Secant of the Course 52 deg. 03 min.	10.2112163

Having both Latitudes and the Course, find the Departure by the 5th Problem, and the difference of Longitude by the 7th Problem.

PROB. X. Both Latitudes, and the Departure given, to find the Course, the distance and the difference of Longitude.



Examp. The *Lizard* in the Lat. 50 deg. 10 min. N. and the East end of St. *Michael's* in the Lat. 37 deg. 54 min. N. the Departure between them 994 min. to find the Course, the Distance and the difference of Longtude.

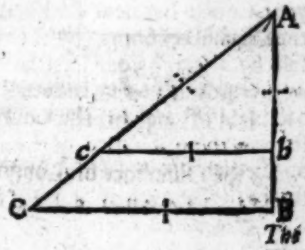
The Operation by the Logarithms. To find the Course.

As the difference of Lat. 736 mim.	2.8668778
To Radius	10.0000000
So is the Departure 944 min.	2.9749720
To the Tang. of the Course 52 deg. 03 min.	10.1080942

Having both Latitudes and the Course; find the Distance by the 5th Problem, and the difference of Longitude found by the 7th Problem.

PROB. XI. One Latitude, the Course and the Departure given, to find the other Latitude, the distance, and the difference of Longitude.

Examp. The Course from the *Lizard* in the Latitude 50 deg. 10 min. N. being S. 52 deg. 30 min. W. and the Departure 944 min. to find the other Latitude, the distance and the difference of Longitude.



The Operation by the Logarithms. To find the other Latitude.

As the Tangent of the Course 52 deg. 03 min.——————10.1079715

To the Departure 944 min.——————2.9749720
So is Radius——————10.0000000

To the difference of Lat. 736 min.——————2.8670005

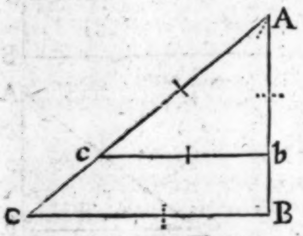
To find the Distance.

As the Sine of the Course 52 deg. 03 min.——————9.8968280

To the Departure 944 min.——————2.9749720
So is Radius——————10.0000000

To the Distance 1197 min.——————3.0781440

Find the difference of Longitude as in the 7th Problem.



PROB. XII. One Latitude, the Distance, and the Departure given, to find the Course; the other Latitude and the difference of Longitude.

Examp. The distance from the *Lizard* in the Latitude 50 deg. 10 min. N. To another part bearing South-westerly is 1197 min. and the Departure between them 944 m. to find the Course, the other Latitude and the difference of Longitude.

The Operation by the Logarithms. To find the Course.

As the distance 1197 min.——————3.0780941

To Radius——————10.0000000
So is the Departure 944 min.——————2.9749720

To the Sine of the Course 52 deg. 03 min.——————9.8968779

Having the Departure and the Courses, find the other Latitude by the 11th Problem, and the difference of Longitude by the 7th.

PROB. XIII. One Latitude, the Distance and difference of Longitude given, to find the Course, the other Latitude and Departure.

PROB. XIV. One Latitude, the Departure, and the difference of Longitude given, to find the Course, the other Latitude, and the Distance.

The Resolution of these two Problems are wanting, to compleat the Doctrine of *Mercator*'s Sailing; and he that shall perform it, will have the Honour to make a further Improvement, in the Science of *Geometry*.

CHAP. X. *Sailing by a Great Circle.*

WE will now shew you the way of Sailing by the Arch of a great Circle, which is the nearest way of Sailing of all others, if a Man may have Winds to keep near the Arch that goes over the two Places propounded; and that there are no Rocks, nor Sands, nor Islands, that lie in the way.

And this Sailing by the Arch of a great Circle, will prove a great advantage when your Course lies near East and West; for Sailing East or West, you trust altogether to the Dead-Reckoning (by the two former ways of Sailing) but by this way you help your self by altering your Latitude several deg. by which you may rectifie your Account. *Example.* Admit you were to sail from *Avero* on the Coast of *Portugal*, to the *Bay* on the back side of *Aquamack* near *Virginia*, which lie both near the Latitude of 40 deg. and suppose the difference of Longitude between these two places be 70 deg. The distance of the two Places East and West is 53 deg. and a half and something more; but the distance in the Arch of a great Circle is but 52 deg. and a little more; that is, 1 deg. and about

about half less, which is but a little benefit to this, which is the chiefest. That in sailing between two such Places by the Arch of a great Circle, you will in the first half of the way raise the Pole 5 deg. 41 min. and then in the other half depress the Pole as much; so that in the whole Voyage you will alter your Latitude 11 deg. 22 m. by several Courses; by which you may rectifie your Dead-Reckoning, which you cannot do in sailing upon a Parallel of East and West; so that you see it is the best way of sailing, as well as the nearest, especially in such Voyages, if the Wind favour you. If the the two Places lie under the Æquinoctial, or under the same Meridian, the distance between them is thus found. If the two Places have no Latitude (being both under the Æquator) the Longitude is the distance in deg. and min. If both Places agreeing in Longitude, have Latitude also of like denomination, (both Latitudes Northerly, or both Southerly) then subtract the lesser out of the greater, the remain is the distance. But if both Places in one Meridian, have one Latitude, and the other Southerly Latitude, add them together, the sum is the distance in Degrees.

This Arch of a Great Circle over two places in Latitude 40 deg. and diff. of Long. 70 d. is the Line P. W. in the Diagram of the 13 Chap. of part of the Globe in Plano.

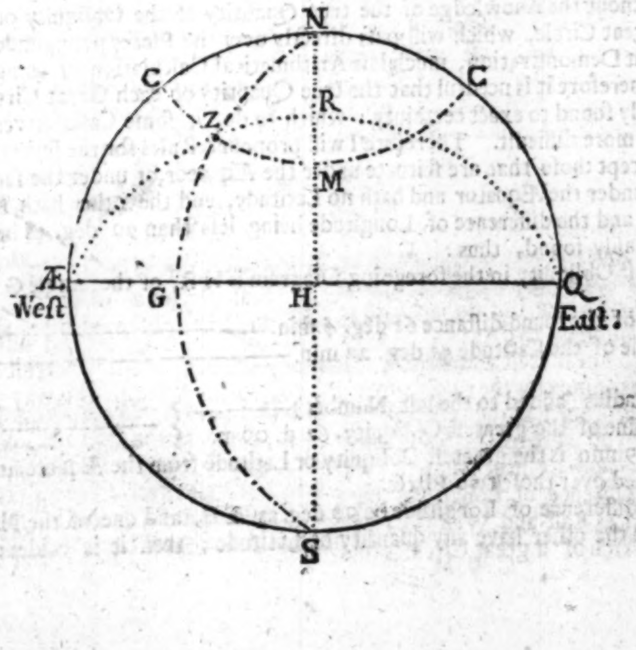
CHAP. XI. *Two known Places, one of them having no Latitud: the other having Latitude and Difference of Longitude; To find,* 1. *Their Distance in a Great Circle.* 2. *The Direct Position of the first Place from the Second.* 3. *And the second Place from the first.*

The First Scituation.

First, If and two Places being proposed, the one under the Æquinoctial, the other being in any other Latitude given, either North or South, and the difference of Longitude of the Places being known; you may find the three things before spoken of, by the following Directions. We call the Angles which the Arch of a Great Circle make with the Meridians of those Places, the Angles of Position. Now in the following Diagram, let Æ be the Entrance of the great River of *Amazons*, under the Æquator; A Q the Æquator, and let C represent the Island of *Lundy*, lying in Latitude, 51 deg. 12 min. Northerly, and C Q the Meridian thereof: and suppose the difference of Longitude A Q to be 41 deg. 22 min.

The Stereographick Projection.

With a Chord of 60 deg. describe the Circle Æ N Q S, and draw the Æquinoctial Æ Q, crossing it at Right Angles with the Line N S N, being the North Pole, and S the South. Let Æ represent the River of the *Amazons*, then by the Line of Natural Tangents, lay off the Tangent of half 48 d. 38 m. the Compl. of the Diff. Long. (viz.



Tang.

Tang. 24 d. 19 m. or 24 d. $\frac{1}{3}$) from H to G, and describe the Meridian N G S. Lay off the Chord of 51 d. 22 m. from Æ and Q to Æ C, and the Tangent of half 51 d. 22 m. (*viz.* 25 d. 41 m.) from H to M, and describe the Parallel Z M C, cutting the Meridian N G S in the Point Z, which represents *Lundy*: then the Arch Æ Z Q, passing by the Point Z, which is the Arch of a Great Circle passing from the *Amazons* to *Lundy*, and Æ Z is the distance in the Arch from the *Amazons* to *Lundy*; and the Angle N Æ Z is the Angle of Position from the *Amazons* to *Lundy*, and N Z Æ is the Angle of Position from *Lundy* to the *Amazons*.

By the Logarithms.

IN the Quadrantal Triangle Æ Z N, there is given N Z, and the Angle Z N Æ, to find Æ Z, and the Angles Z Æ N and Æ Z N; or in the adjacent Right-angled Triangle Æ Z G (Right-angled at G) there is given G Z the Complement of N Z to 90 deg. and Æ G the measure of Æ N Z, to find Æ Z and the Angles G Æ Z (and the Complement of N Z Æ to 180 deg.) and G Æ Z the Complement Z Æ N to 90 deg.

For the Distance in the Arch Æ Z.

As Radius is to the Co-sine of difference of Longitude 41 deg. 22 min. —— 987534
So is Co-sine of the Latitude 51 deg. 22 min. —— 979541

To the Co-sine of the Distance 62 deg. 04 min. —— 967075

Which converted into Leagues, is 1237$\frac{1}{3}$ the nearest distance between those two Places.

For the Angle of Position from the *Amazons* towards *Lundy*, G Æ Z the Complement of N Æ Z to 90 deg.

As the Radius to the Sine of the Diff. of Longitude 41 deg. 22 min. —— 982011
So is the Co-tangent of the Latitude 51 deg. 22 min. —— 990267

To the Co-tangent of the Angle —— 972278

For the Angle of Position G Æ Z, 62 deg. 10 min. whose Complement to 90 deg. is 27 deg. 50 min. the Angle N Æ Z from the *Amazons* to *Lundy*.

As Radius 90 is to Sine of the Latitude 51 deg. 22 min. Q C —— 989273
So is Co-tangent of Diff. of Longitude 41 deg. 22 min. A Q —— 1005522

To the Co-tangent of the Angle Æ Z G 48 deg. 26 min. —— 994795

Whose Complement to 180 deg. is 131 deg. 34 min. the Angle Æ Z N.

PROB. 2. *How to find the Great Circle's greatest Lat. N. or S. or the Obliquity.*

NOte, Without the Knowledge of the true Quantity of the Obliquity or Latitude of that Great Circle, which will pass directly over the Places propounded, there can be no compleat Demonstration, much less Arithmetical Calculation of things pertaining thereunto; therefore it is needful that the true Quantity of each Great Circle's Obliquity be diligently found to exact certainty: which to do, it some Cases is very easie, and in some again more difficult. Therefore I will propound Rules for the several Scituations following, except those that are scituate under the Æquator, or under the same Meridian. one Place be under the Æquator and hath no Latitude, and the other hath any quantity of Latitude, and the difference of Longitude being less than 90 deg. as before 41 deg. 22 min. it is easily found, thus:

The greatest Obliquity in the foregoing Diagram is H R, or the Angle G Æ Z.

As the Sine of the found distance 62 deg. 4 min. —— 994620
Is to the Sine of the Latitude 51 deg. 22 min. —— 1989273

So is the Radius (added to the last Number) } —— 994653
To the Sine of the greatest Obliquity 62 d. 09 m. }

So 62 deg. 9 min. is the greatest Obliquity or Latitude from the Æquator, of that Great Circle extended over those two Places.

But if the difference of Longitude be 90 deg. as Æ H, and one of the Places have no Latitude, and the other have any quantity of Latitude; then it is evident to Reason, as

as in the foregoing Diagram may appear, that the second Place is scituate in the Point of the greatest Obliquity, which is never above 90 deg. as H N; and the other Place being in the Point of Intersection of the said Great Circle with the Æquator.

For Note, That every Great Circle that passeth over any two Places propounded, cuts the *Æquator* in two opposite Points 180 deg. from each other, as the Ecliptick Line doth in the two Points of *Aries* and *Libra*, whose greatest Obliquity 23 deg. 30 min. the *Sun's* greatest Declination.

Now if one Place have no Latitude, no deg. no min. and the other have any quantity of Latitude, the Difference of Longitude being more than 90 deg. to find the Obliquity of the Great Circle passing over those Places; Proceed thus,

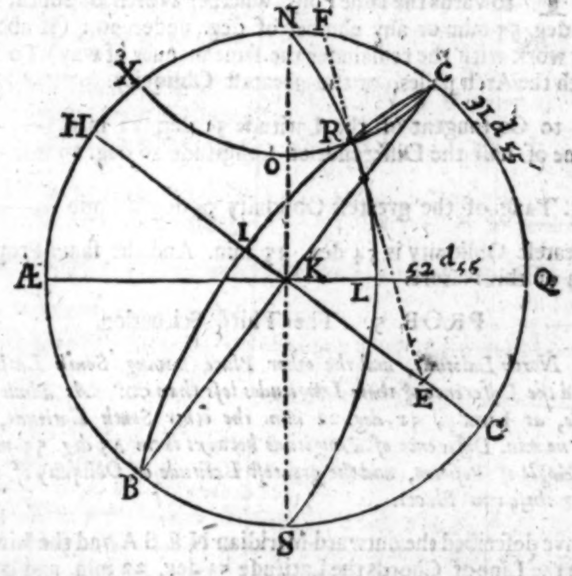
As admit one Place Latitude no deg. no min. and the other 51 deg. 22 min. Difference of Longitude 138 deg. 38 min. distance betwixt them is near 117 deg. 56 min. Therefore take the distance out of 180, and there remains 62 deg. 04 min.

As the Sine of the remainder 62 deg. 04 min.	994620
Is to the Sine of the Latitude 51 deg. 22 min.	989273
So is Radius	10
To the Sine of the greatest Obliquity 62 deg. 09 min.	994653

As in the former Example; And so you may make for any Questions of this nature.

The Second Scituation.

SEcondly, There may be two Places both Scituated in any Parallel of Latitude, betwixt the *Artick* and *Antartick Poles*, differing only in Longitude.



PROB. 3. *Admit there be two Places both in the Latitude of 51 deg. 22 min. and their Difference of Longitude be 52 deg. 55 min. 1. To find the nearest Distance of those two Places. 2. The direct Position of the one Place from the other.*

The Stereographick Projection.

HAving drawn the Circle N Q S Æ and the Lines N S and Æ Q, take off the Line of Chords, the Latitude of the Place 51 deg. 22 min. and lay from Æ X, and from Q to C; and take off the half Tangent the same Latitude, and lay from K to O; and through these three Points draw the Parallel of Latitude X O C; the Complement of the Difference of Longitude laid from R to L by the half Tangents draw the Meridian Circle N L S; the second Place is at R, and first at C; therefore draw the Circle from C

 through

through R to B, and measure K I on the half Tangents, and you will find it 21 deg. and a Quarter, Complement to 90 deg. is 68 deg. three quarters the Angle of Position N C R. Now from the half Tangents take 68 deg. and three quarters, and lay it from the Center K to E, and from E draw through the Point of Intersection at R the prickt Line B R F; and measure C F on the Line of Chords, and you will find it 32 deg. and a quarter for the Great Circle's Distance.

In the Seventh Problem of sailing by *Mercator*'s Chart, you may see there was required the Distance of these two Places measured in the Parallel, and found to be 660. But here is required the nearest Distance in the Arch of a Great Circle: Work thus by the Tables of Logarithms.

For the Distance,

As the Radius, is to the Sine Compl. of the Latitude 38 deg. 38 min. —— 979541
So is the Sine of half the Diff. of Longit. 26 deg. 27 min. —— 964876

To the Sine of half the Distance 16 deg. 09 min. —— 944417

Which doubled is 32 deg. 18 min. and this converted into Leagues and Miles, is 646 Leagues, and 1938 Miles, the nearest Distance; and less than the Distance measured in a Parallel by Miles 42.

To find the Angle of Position,

As Radius 90, is to the Sine of the Lat. 51 deg. 22 min. —— 989273
So is the Tangent of half the Diff. of Longitude 26 deg. 27 min. —— 969678

To the Co-tangent of the Angle of Position 68 deg. 46 min. —— 958951

PROB. 4. TWO Places having both the same Latitude, as 51 deg. 22 min. and towards the same Pole, whether North or South, and Difference of Longitude 52 deg. 55 min. or any number of deg. under 90: (If above 90; take it out of 180, and work with the remainder the same manner of way) To find the greatest Latitude by which the Arch passes, or the greatest Obliquity.

As Radius 90, to Co-tangent of the Latitude 51 deg. 22 min. —— 990267
So is the Co-sine of half the Difference of Longitude 26 deg. 27 min. —— 995197

To the Compl. Tang. of the greatest Obliquity 54 deg. 25 min. —— 985464

So that the greatest Obliquity is 54 deg. 25 min. And the same Proportion will hold for any Question of this Nature.

PROB. 5. The Third Scituation.

One Place having North Latitude, and the other Place having South Latitude, of different Quantities, and the Difference of their Longitudes less than 90. As admit one Place having North Latitude, as Lundy, *51 deg. 22 min. the other South Latitude, as the* Rio de la Plata, *35 deg. no min. Difference of Longitude betwixt them 45 deg. 55 min. I demand the Distance, the Angle of Position, and the greatest Latitude or Obliquity of the Great Circle that passeth over these two Places.*

AFter you have described the outward Meridian N E S A, and the Lines N S and A E, take from the Line of Chords the Latitude 51 deg. 22 min. and lay it from E to P, and draw the Line P C O, and H C M at Right Angles to P O, take off the Line of half Tangents, the Complement of the Difference of Longitude, to 90 deg. *viz.* 44 deg. and lay it from E to F, and draw the Meridian-Circle N F S, whereon lay the Latitude, of *Rio de la Plata* 35 deg. from F to R, by taking 35 out of the Line of Chords, and laying it from E to 35, and the half Tangent of 46 deg. from C to the Pole, and draw the prickt Line Pole 35, which cuts the Circle N F S in R, which is *Rio de la Plata*; and through R draw the Circle P R O, and measure C N on the half Tangents, you will find it to be 54 deg. to which adding 90 deg. makes the Angle of Position N P R, 144 deg. Then take the half Tangent of 36 deg. and lay from C to K, and draw the prickt Line from K through R, and it will cut the Circle N E S A at T; therefore measure T P on the Line of Chords, and that is the measure of R P 95 deg.; for the Distance, the greatest Latitude or Obliquity is V L W, which touches the Parallel of 68 deg.; the greatest Circle P R O.

By

By the Logarithms; To find the Distance in the Arch.

As Radius to the Co-sine of Differ. of Longitude 45 deg. 55 min.——— 984242

So is the Co-tangent of the greater Latitude 51 deg. 22 min.——— 990267
To the Tangent of the first Arch 29 deg. 05 min.——— 974509

The less Latitude 35 deg. and 90 d. makes 125 d. Take the first Arch 29 d. 5 min. therefrom, and there remains 95 d. 55 m. which is the second Arch. Then,

As Co-sine of the first Arch, 29 deg. 05 min.——— 994146

Is to the Co-sine of the second Arch 95 deg. 55 min.——— 901318
So is the Sine of the greater Latitude 51 deg. 22 min.——— 989273

Out of——180 d. no m.			
Take——84 43	To the Co-sine of 95 d. 17 m.———	1890591	Sum
And there remains--95 17	The Distance———	896445	

To find the Angles of Position, NPR *and* PRN, *in the Oblique Triangle* NPR.

Co. Arith.

As Sine PR the Distance in the Arch 95 deg. 17 min.——— 0.00185
To Sine PNR the Diff. of Longitude 45 d. 55 m.——— 9.85632
So is Sine NR the lesser Latitude 35 d. and 90 d.—125 d. no min.——— 9.91336

To Sine NPR 143 d. 47 m. which is the Angle of Position from *Lundy* to *Rio de la Plata*.——— 19.77153

Co. Arith.

Then as Sine PR the Distance in the Great Circle 95 d. 17 m.——— 0.00185
To Sine PNR the Difference of Longitude, 45 d. 55 m.——— 9.85632
So is Sine NP the Compl. greater Latitude, 38 d. 38 m.——— 9.79542

To Sine NRP 26 d. 46 m. is the Angle of Position from *Rio de la Plata* to *Lundy*——— 19.65359

To find the Obliquity, or the greatest Latitude by which the Arch passes.

As Radius to the Co-sine of the greater Latitude, 51 d. 22 m.——— 979542
So is the Sine of the greater Angle of Position 143 d. 47 m.——— 977147

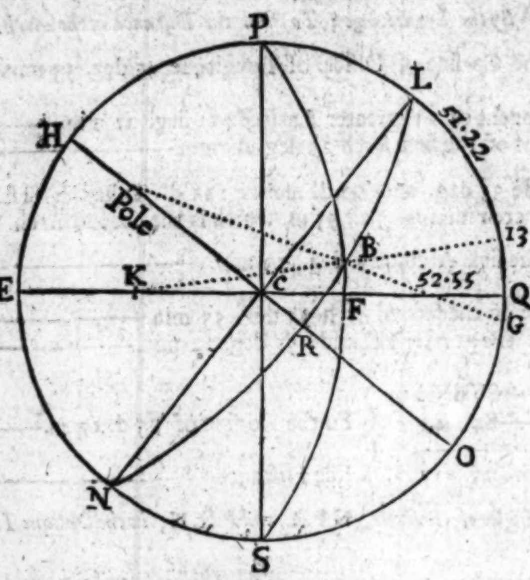
To the Co-sine of the greatest Latitude, which is 68 d. 22 m.——— 9.56689

PROB. 6. The Fourth Scituation.

The Latitude of two Places both in one Hemisphere being given, together with the Difference of Longitude; to find, First, the Distance in the Arch of a Great Circle. Secondly, The Angle of Position from the first Place to the Second. And, Thirdly, from the Second Place to the first. And Fourthly, The Circle's greatest Obliquity that passeth over those two Places.

ADmit L H be *Lundy* in the Latitude, 51 deg. 22 min. and Longitude 25 deg. 52 min. (from the West end of St. *Michael's* and B the *Barbadoes* in the Latitude 13 deg. 10 min. and Longitude 332 deg. 57 min. and Diff. of Long. 52 deg. 55 min.

Lay down first the Latitude 51 deg. 22 min. from Q to L; Secondly, the Difference of Longitude Q F 52 deg. 55 min. and draw the Meridian-Circle P F S; then lay down the Latitude of *Barbadoes* from Q to 13, and take of the half Tangent Line Q F 52 deg. 55 min. and lay from C to K, and draw the prickt Line, which will cut the Meridian-P F S in B, the Latitude of *Barbadoes*, 13 deg. 10 min. Through B draw the Circle L B N, so the Angle of Position from *Lundy* to the *Barbadoes* is B L P, whose measure is H I 12; then take off the Line of half Tangents, 68 deg. and lay it from C to Pole, and the Line from Pole through B, and it will cut the Limb in G: Therefore measure G L on the Line of Chords, you have 57 deg. for the Distance.



To find the Distance by the Logarithms.

As the Radius, is to the Co-sine of Diff. of Longit. 52 deg. 55 min. ——— 978030
So is the Co-tang. of the greater Latitude 51 deg. 22 min. ——— 990167

To the Tangent of the first Arch 25 deg. 44 min. ——— 968297

Take 25 deg. 44 min. from 76 deg. 50 min. the Complement of 13 deg. 10 min. the less Latitude, and the remain is 51 deg. 06 min. the second Arch.

As the Co-sine of the first Arch 25 deg. 44 min. —— 995464
Is to the Co-sine of the second Arch 51 d. 06 m. —— 979793
So is the Sine of the greater *Latitude* 51 d. 22 m. —— 989273
} To find the Distance.

1969066

To the Co-sine of the Distance 57 d. no m. —— 973602

Which is the Distance in the Arch of a Great Circle, being 17 *Leagues* less than by *Mercator*'s Chart, and less by 166 *Leagues* than by the Rhomb on the *Plain Chart*; which confirms this to be the nearest of all ways of Sailing betwixt any two Places.

To find the Angle of Position from Lundy *to* Barbadoes.

L As the Sine of the Distance 57 deg. no min. ——— 992359

Is to the Sine of the Difference of *Longitude* 52 deg. 55. min. ——— 990187
So is the Co-sine of the less *Latitude* 13 deg. 10 min. ——— 998843

1989030

To the Sine of the Angle of Position ——— 996671
Which is 112 deg. 09 min.

To find the Angle of Position from Barbadoes *to* Lundy.

As the Sine of the Distance 57 deg. no min: ——— 992359

To the Sine of the *Difference* of *Longitude* 52 deg. 55 min. ——— 990187
So is the Co-sine of the greatest Latitude 51 deg. 22 min. ——— 979541

1969728

To Sine of the Angle of Position 36 deg. 26 min. ——— 977369

To

To find the Obliquity.

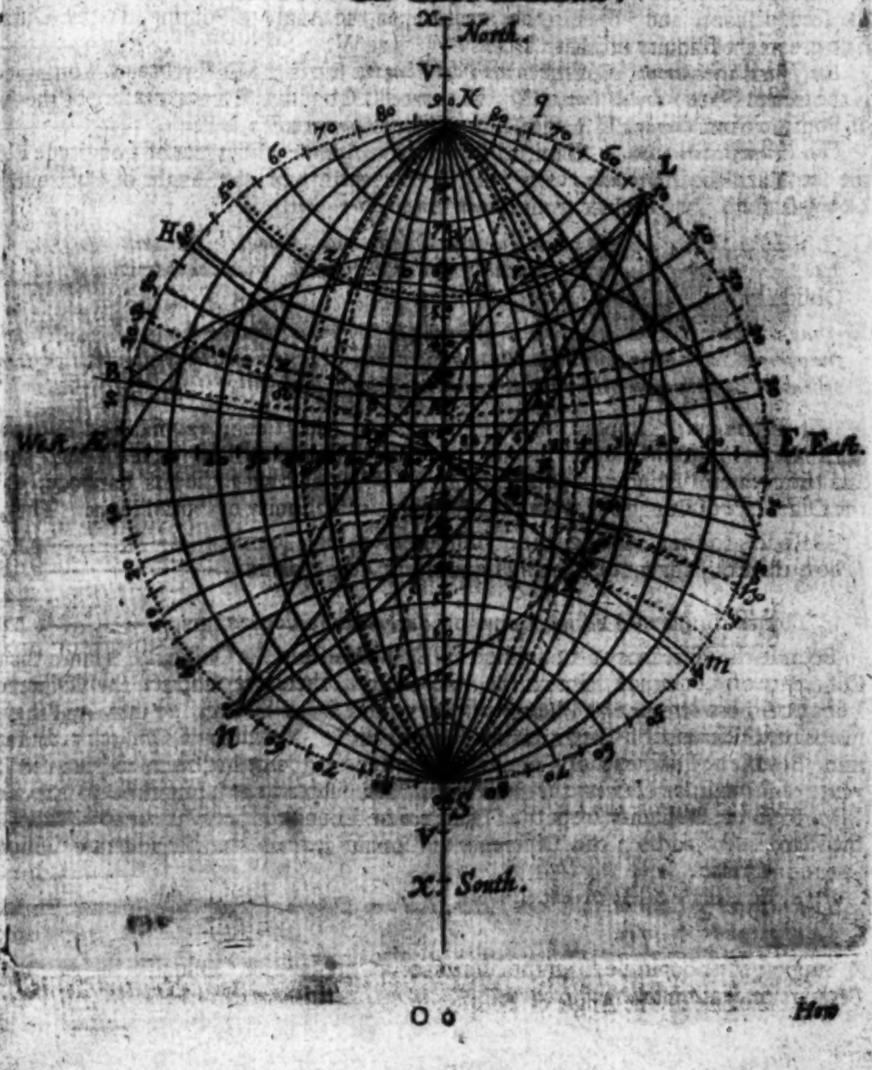
As Radius to Co-sine of less Latitude 13 deg. 10 min.——————998843
So is the Sine of the lesser Angle of Position 36 deg. 26 min.——————977370

To the Co-sine of the greatest Obliquity 54 deg. 40 min.——————976213

CHAP. XII. *To describe the Globe in* Plano, *by the Mathematical Scale.*

THese, and all other Questions of this Nature, concerning the Resolution of any Spherical Triangle, may very easily be performed by the Globe: But because the Globe is a chargeable Instrument, and so every one cannot have it, therefore several Men have invented divers ways to project the Globe upon a Plain, as *Gunter* hath them in his Book of the *Sector*. The fittest for this purpose will be that of *Gemma Frisius*, which is most used in the large Maps of the World, the Projection whereof is as followeth. First, By the Chord of 60 deg. describe the Circle Æ N E S, and by the Chord of 90 deg. divide it into four parts as Æ E for the *Æquator*, and N S for the primary Meridian: Then by taking off every 5 deg. of the Chord, you may divide each Quadrant, and number them as in the Figure: Then take off your Line of half Tangents in your Scale every 5 deg. and lay them from the Center C on the four Quadrants, and number them as they are in the Figure; so shall you divide the Diameters Æ E the Æquinoctial, and N S the Meridian. Now you have divided the Diameters, they will guide you in the drawing of the Meridians from Pole N to Pole S, which are Circles; as likewise are the Parallels of Latitude.

The Globe in Plano.



 How

How to find the Centers of the Meridian Circles.

You may find the Centers in the Diameter Æ E, if you extend the Compasses to the Secants of every 10 deg. and with that Distance put one Point at 10 deg. in the Semi-diameter Æ C, and the other Point will fall in E C, and be the Center of the Meridian of the first 10 deg. from Æ, and do the like for any other deg. continuing the Diameter when need shall require it.

How to find the Centers of the Parallels of Latitude.

For the Parallels of Latitude, take the Complement of the Latitude from your Line of Tangents, put one Point in the deg. of Latitude, the other will stand in the Center.

Example. If you will draw the Parallel of Latitude for 60 deg. take off the Tangent line of your Scale 30 deg. the Compl. 60 deg. of Latitude, and the other will fall upon V the Center of the Parallel of 60 deg. in the Semi-diameter N S, continued beyond the Circle. So take the Tangent of 40 deg. and it will draw the Parallel of 50 deg. whose Center is at X, and so do in drawing all Parallels of Latitude.

The Four Scituations that are on the Globe.

The First Scituation. Æ is the Point for the Mouth of the River of *Amazons*, Z *Lundy*, C R the Obliquity, E the other Point of Intersection with the Æquator, N R the measure of the Angle of Position from *Amazons* to *Lundy*, Æ Z the Distance from *Amazons* to *Lundy*.

The Second Scituation. L is the first Place, E F is the Difference of Longitude, ♈ is the second Place, and ♍ H is the measure of the Angle of Position, l r the Distance. The greatest Obliquity of that Circle N r l. is at W.

The Third Scituation. L is the first Place *Lundy*, E p is the Difference of Longitude, R is the second Place *Rio de Plata*, S △ the greatest Obliquity, H n the measure of the Angle of Position from *Lundy*, L R the Distance from *Lundy* to *Rio de Plata*.

The Fourth Scituation. The first Place is at L, *Lundy*; Difference of Longitude is E F, the second Place *Barbadoes* at b; H ♍ is the measure of the Angle of Position from *Lundy*, and b L the Distance from *Lundy* to the *Barbadoes*.

CHAP. XIII. *How to calculate what Degree and Minute of Latitude the great Circle shall pass through for any Degree and Minute of Longitude, from the Meridian of the greatest* Obliquity.

By the Latitude of two Places, the Difference of Longitude betwixt them and the Obliquity of the great Circle passing over both Places being given; to find the Difference of Longitude of each Place from the Meridian of the greatest Obliquity.

Let this be our Example. *Lundy* in North Latitude 51 deg. 22 min. and *Barbadoes* in North Latitude 13 deg. 10 min. and the Difference of Longitude 52 deg. 55 min. and the greatest Obliquity 54 deg. 40 min. Work first with the less Latitude, to find the Difference of Longitude from the Meridian of Obliquity of both Places. Thus,

As Radius to the Co-Tangent of Obliquity 54 deg. 40 min.———— 9.85059
So is the Co-Tangent of the less Latitude 13 deg. 10 min.———— 9.36909

To the Co-sine of Diff. of Long. of *Barbadoes* 80 deg. 27 min.———— 9.21968

Because the difference of Longitude of *Barbadoes* from the Obliquity is more than the Difference of Longitude betwixt the two Places, therefore subtract the Difference of Longitude between the two Places 52 deg. 55 min. from 80 deg. 27 min. and there remains the Difference of Longitude of *Lundy* from the Meridian of Obliquity 27 deg. 32 min. But if the Difference of Longitude from the Obliquity had been less than the Difference of Longitude betwixt the two Places, then subtract the Longitude of the second Place from the Obliquity from the Difference of Longitude betwixt the two Places, and the Remainder had been the Difference of Longitude from the Meridian of Obliquity, to the first Place

To find by what Latitude the Arch shall pass at any Degree of Longitude from the Meridian of the greatest obliquity.

Suppose the Longitude from the Meridian of the greatest Obliquity be 30 deg. the Proportion is as follows.

As

As Radius to Tangent of Obliquity 54 deg. 40 min.—————————— 10.14941
So is the Co-sine of Diff. of Longitude from Obliq. 30 deg. 00————— 9.93753

To the Tangent of the Latitude 50 deg. 42 min.—————————— 10.08694

After the same manner I made this Table of an Arch of a great Circle, extended from Latitude 51 deg. 22 min. to Latitude 13 deg. 10 min. Difference of Long. 52 deg. 55 min. for every 5 deg. 55 min. that is, for every 5 deg. Difference of Long. These are the Latitudes the great Circle will pass through.

Diff. of Longit. from Obliq. Lundy.		Latitude.	
Deg.	Min.	Deg.	Min.
27	32	51	22
30	00	50	42
35	00	49	07
40	00	47	13
45	00	44	56
50	00	42	12
55	00	38	58
60	00	35	12
65	00	30	47
70	00	25	46
75	00	20	03
80	27	13	10

CHAP. XIV. *By the Scale of Tangents to project part of the Globe in* Plano, *whereby you may trace out the Latitudes to every Degree of Longitude, or to every 5 or 10 Degrees.*

BY the Line of Tangents on the side of your Mathematical Scale, you may make the following Projection, which is performed by *Philips* in his Geometrical Seaman, *pag.* 5, by Tables.

First, Consider your least Latitude, and take the Comp. thereof, and set it off from A towards D, as I have done, by taking of 77 deg. from the Tangent-line of my Scale, and setting it from A the Pole to D, for 13 deg. on the North side of the Æquator, or 13 deg. of North Latitude, (which is the Complement of 13 to 90 deg.) Then make the other side of the same length, and draw the Quadrant D E: Then with your Compasses take off the Line of Tangents the several Degrees, and draw the Arches or Parallels of Latitude, as you see I have done in the Figure. Thirdly, divide the Limb of the Arch D E into 90 deg. and through every 5 or 10 deg. draw Lines of Longitude, or Meridian-Lines. The Arches of Latitudes must be numbred as in the Figure; but the Lines of Longitude you may number from either side, as occasion requires.

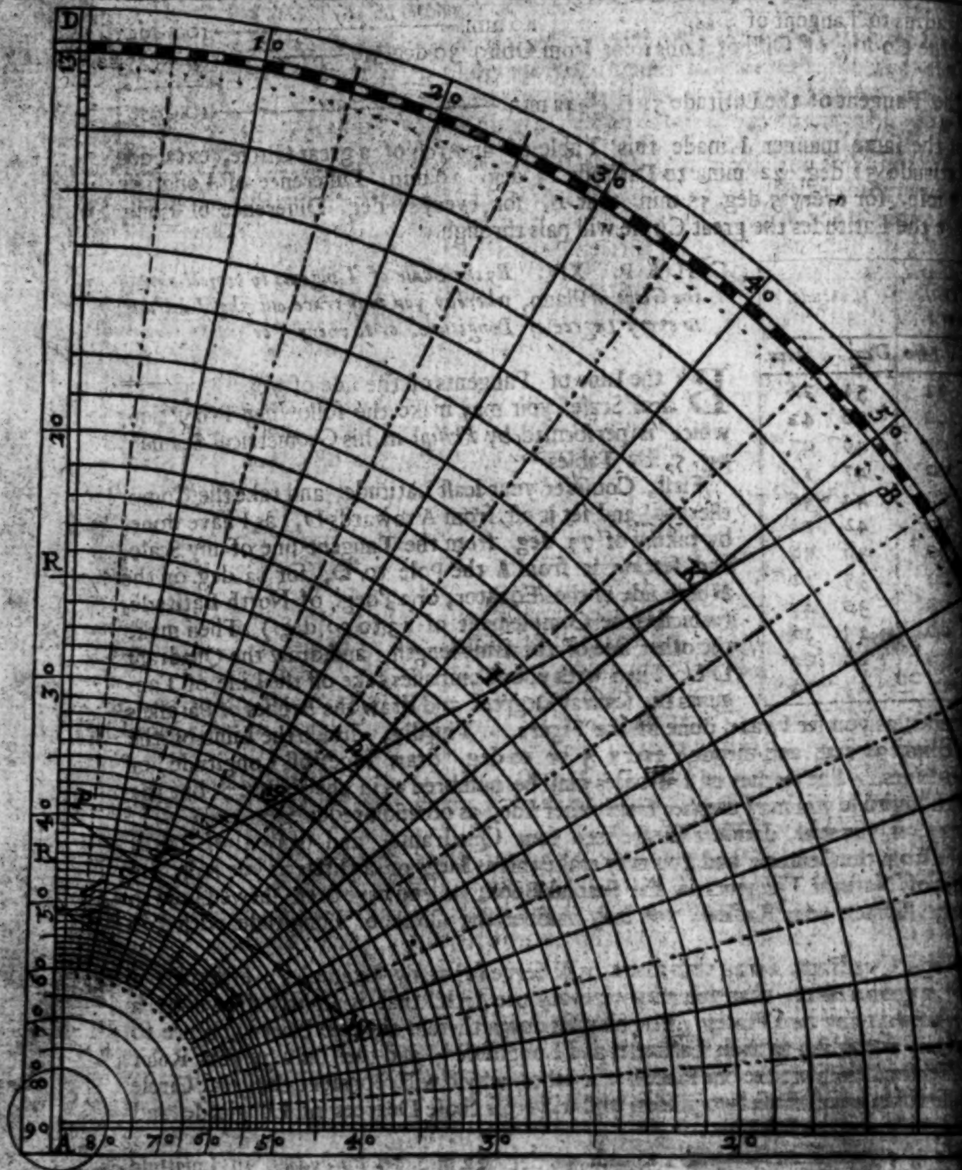
You may, if you will, divide a Circle into four Quadrants, and draw the Lines of Longitude from the Center; and you may make this as large or as little as you will, by the Tables of Natural Tangents in the Second Book, as you have been shewed how to lengthen or shorten your Radius; you may number the Circle of Longitude with 360 Degrees.

The Blank Quadrant, being thus made, will serve for many Examples; especially if you make it upon a Slate, that you may wipe out the Arch, that is lightly drawn by a Slate Pen betwixt any two Places. You may set down therein the two Places you are to sail between, according to their Latitudes and Longitudes; and then only by your Ruler draw a streight Line from the one Place to the other, which will represent the great Circle which passeth between those two places, and will cross those Degrees of Longitude and Latitude which you must sail by.

Suppose a Voyage from *Lundy* in Latitude 51 deg. 22 min. to *Barbadoes*, in Latitude 13 deg. 10 min. Difference of Longitude 52 deg. 55 min. to find by what Longitude and Latitudes the Arch of a great Circle drawn between those two Places doth pass.

First, Let the Line A D represent the Meridian of the Island of *Lundy*, marked out by L for its Latitude 51 deg. 22 min. and the Longitude thereof 25 deg. 52 min. at D. Then from D in the Limb or Arch of the Quadrant, count the Diff. of Long. 51 deg. 55 min. and this is the Meridian of the Island of *Barbadoes*, on which you must mark out the Latitude 13 deg. 10 min. at B; lay a Ruler from the first Latitude L, to the second at B, and draw the streight Line L B which representeth the Arch of a great Circle between the two Places; and if you guide your Eye along in this Line, you may readily and truly perceive by what Longitudes and Latitudes you should sail: For where this Line crosseth the Arches of Latitude, and the Lines of Longitude, that shews the true Longitude and Latitude of the Arch according to your desire. Now the truth hereof will more evidently appear, if you compare the Latitudes and Longitudes which this Line intersecteth, with the Table, before calculated for every 5 deg. of Longitude.

Difference



Difference of Longitude		Difference of Longitude from Obliquity.		Latitude.		Difference of Longitude from Lundy.	
D.	M.	D.	M.	D.	M	D.	M.
52	55	7	32	51	22	00	00
2	28	30	00	50	41	02	28
5	00	35	00	49	07	07	28
5	00	40	00	47	13	12	28
5	00	45	00	44	59	17	28
5	00	50	00	42	12	22	28
5	00	55	00	38	58	27	28
5	00	60	00	35	12	32	28
5	00	65	00	30	48	37	28
5	00	70	00	25	46	42	28
5	00	75	00	20	30	47	28
5	27	80	27	13	10	52	55

You may see by the Figure, that the Line B L in Points a, b, c, d, e, F, g, h, i, k, B doth cross Parallel of Latitude, in the third Column of this Table, at the number of Degrees from the Meridian *Lundy*, as in the 4*th* Column of the Tables.

Example.

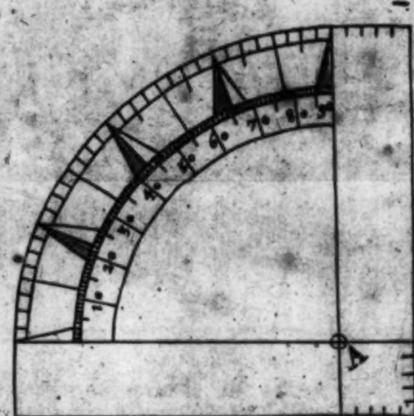
I would know what Degree of Latitude 47 d 28 min. of Longitude from the first Meridian doth cross; and I see by the Figure it is as the Table sheweth at 20 deg. 30 min. of Latitude.

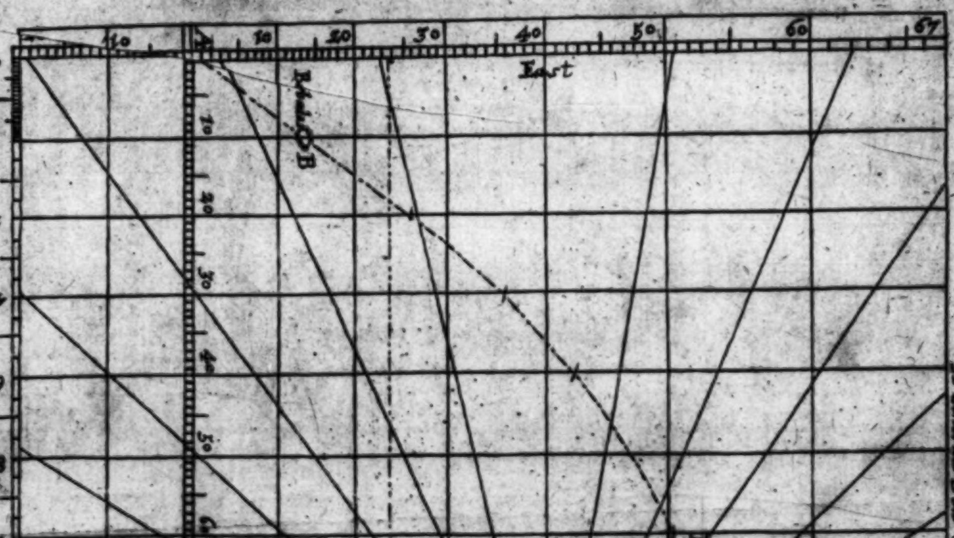
And so in like manner you may lay down upon the former Quadrant any two places howsoever scituated by their Latitude and Difference of Longitude.

CHAP.

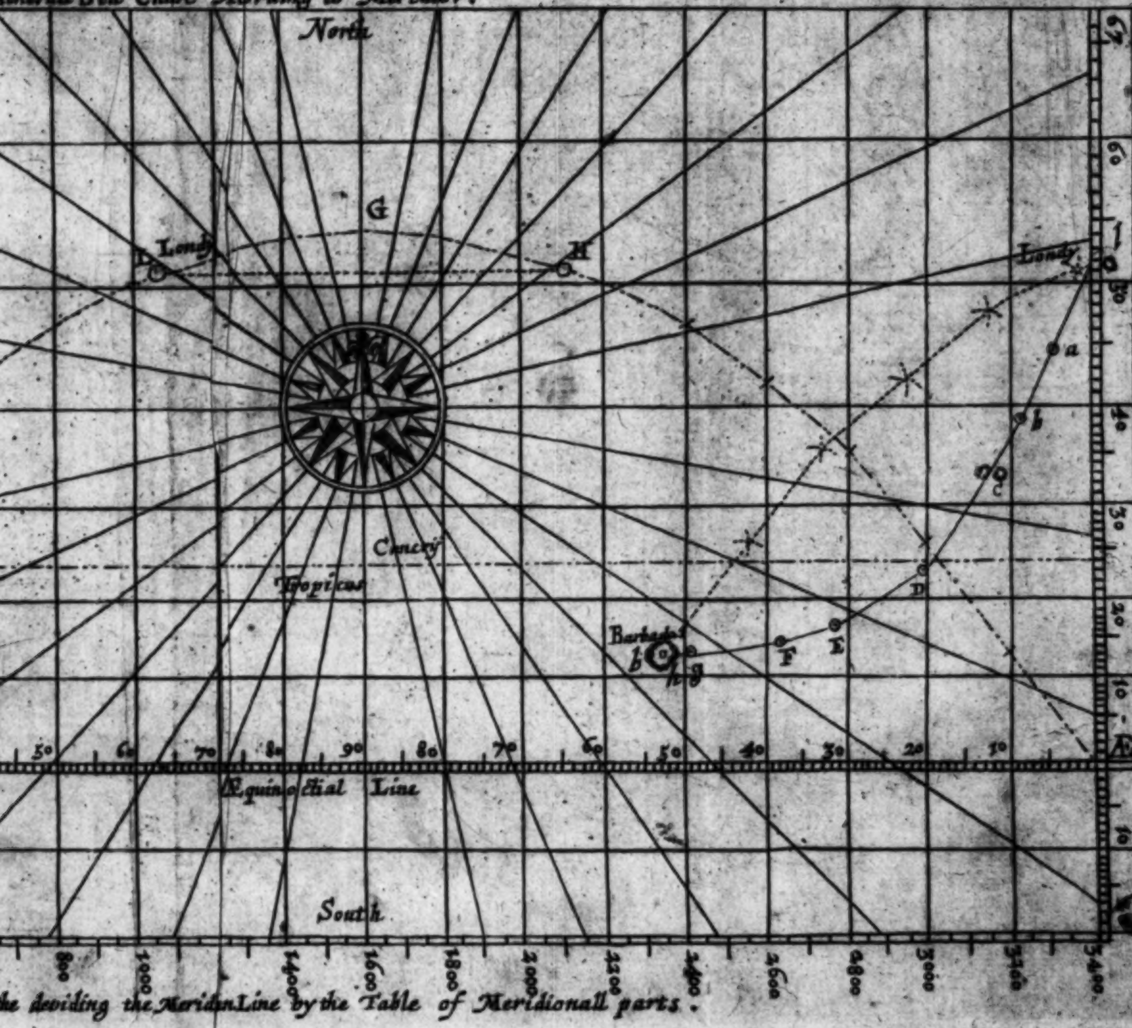
The Index

Fasten this in with a Rivet to the Center of the Quadrant A. that it may turne upon it with a hole through the Rivet .





...enerall Sea Chart According to Mercator.



...the deviding the Meridian Line by the Table of Meridionall parts.

CHAP. XV. *Containing several Propositions of Great Circle-Sailing.*

PROB. I. *By the Latitude, and Difference of Longitude from the Obliquity, to find the great Circle-Distance from the greatest Obliquity.*

As Radius 90, to Co-sine of the Latitude 51 deg. 22 min. —— 9.79541
So is the Sine of the Difference of Longitude 27 deg. 32 min. —— 9.66489
To the Sine of the Distance 16 deg. 47 min. —— 9.46030

So that 16 deg. 47 min. is the great Circle Distance from the Point of the greatest Obliquity of that Circle.

PROP. II. *By the Obliquity of the great Circle, to find the Latitude at any Distance, from the Point of the greatest Obliquity.*

As Radius, to Sine of greatest Obliquity 54 deg. 40 min. —— 9.91158
So is Co-sine of the Distance from Obliquity 16 deg. 47 min. —— 9.98109
To the Sine of the Latitude 51 deg. 21 min. —— 9.89267

Again. As Radius, to Sine of greatest Obliquity 54 deg. 40 min. —— 9.91158
So is Co-sine of Distance from Obliquity 73 deg. 47 min. —— 9.44602
To the Sine of the Latitude of *Barbadoes* 13 deg. 10 min. —— 9.35760

PROP. III. *By the Great Circle's Distance from the Point of Obliquity, and the Latitude given, to find the Diff. of Long. betwixt that place and the Meridian of greatest* Obliquity.

As the Co-sine of the Latitude 51 deg. 22 min. —— 9.79541
To Radius, so is the Sine of the Dist. from the Obliquity 16 d. 47 m. —— 19.46052
To the Sine of the Diff. of Longit. 27 deg. 33 min. —— 9.66511

PROP. IV. *By the great Circle-Distance from the Obliquity, and the Latitude given, to find the Angle of Position.*

As Radius 90 deg. to Tang. of great Circle Dist. 16 deg. 47 min. —— 9.47943
So is Tangent of the Latitude 51 deg. 22 min. —— 9.90267
To Co-sine of the Angle of Position 67 deg. 50 min. —— 9.57676

CHAP. XVI. *How to make the true Sea Chart, and the Use thereof in* Mercator's *and Great Circle Sailing, being a general Chart.*

FOR the manner of the Division, let the Æquator be drawn and divided, and crossed with Parallel Meridians, as before directed; only one degree of Longitude in the Particular Chart before-going, is 10 deg. of the Æquator of this General Chart. You have been directed how to make the Meridian-line off the Scale for a Particular Chart, and the same Rule makes this. Look in the Table of Meridional parts, and you will find the Difference between the Æquator and 40 deg. of Latitude in the Meridian-line to be 874,2 which is 874 Leagues $\frac{2}{10}$; and that divided by 20 is 43 deg. 42 min. of the Æquator, therefore out of a Scale of Equal parts, each deg. of the Æquator, being divided into 20 parts, take 874 parts, and that Dist. will reach from the Æquator to 40 d. of Lat.

And for 50 deg. take 1158 such Equal parts (which is 57 deg. 54 min.) which will reach from the Æquator, to 50 deg. of Latitude in the Meridian-line: And so do for any other d. or m. of Lat. until you have made the Chart, as I have done in the Figure.

The Protracting Quadrant (you may see the Figure) shews you at sight, without more words, how to make it by dividing it into eight Points, and each Point into four quarters, and the Arch within into 90 deg. and a Label or Index to be riveted to the Center, and a hole drill'd through the Rivet to put a Pin through the Center of the Quadrant, to lay it upon any place assigned, and let it square by the Meridian and Parallels of Latitude; so laying the Center to the first place and Index over the second place, the Limb of the Quadrant will shew you the Point of the Compass, or what Angle it makes with the Meridian, *viz.* the bearing of the first place from the second. Now to trace out the Arch of a Great Circle, betwixt the places in *Mercator's* Chart, in Chap. 13. you have the way how to calculate for any Obliquity, and to any deg. of Longitude, what deg. and min. of Latitude the Great Circle shall pass through; by the same Rules I have calculated, for every 10 deg. of Longitude, reckoning from the greatest Obliquity, to the Intersection of the Great Circle with the Æquator, *viz.*

Greatest Obliquity G 54 deg 40 min.

For Deg. Long.	10	20	30	40	50
the Deg. Lat.	54 d. 15 m.	52 : 58	50 : 41	47 : 15	42 : 12

For Deg. Long.	63	70	80 : 27	For 90 Deg. Longit.
Degr. Lat.	35 : 12	25 : 46	13 : 10	are 00 Deg. Lat.

In the *Mercator's* Plat, G standeth at 54 deg. 40 min. of North Latitude, and Æ just 90 deg. of Longitude Westward, and Æ N 90 deg. Eastward from G, being the two opposite *Points* in the Æquator, 180 deg. from each Point of Intersection Æ Æ.

In every Meridian betwixt G and Æ, on both sides (the Meridians being drawn at every 10 deg. of Longitude in the Chart) make a mark at the Latitude found in the Table, taking it from the Meridian-line of the Chart; and having so marked every Meridian, then by these marks draw Arches from one to another: or it will suffice to draw Right-lines from Mark to Mark, as from G (the greatest Obliquity of the Great Circle) to the next Meridian on each side; and so to the next, until you come down to the Æquator at Æ on both sides; so have you pourtray'd on this *Mercator* Plat a Great Circle from *Lundy* to *Barbadoes*, one being in North Latitude 51 deg. 22 min. at L, the other at B in North Latitude 13 deg. 10 min. with difference of Longitude 52 deg. 55 min.

He that will take the pains, will find great delight in the Great-Circle-Sailing. Yet I conclude, That although it is the nearest way, it is not always the convenientest way for Sea-men, for several Reasons known to them that can keep an Account of the Ships way, both by *Mercator's* and Great-Circle-Sailing, which I could lay down here; but in regard it is needless, I leave every one to his Discretion, and shall shew you the way how I did keep my Account at Sea, by *Mercator's* Chart.

CHAP. XVII. *How to keep a Sea-Journal.*

I Would not have any Ingenious Artist, that hath a long time kept Account of a Ships way, to think I prescribe him Rules, but only give Direction to young Learners, that so they may have a perfect Method of keeping Account of a Ship's way at Sea.

To do this, I conceive it will be fit to have a Book in Folio, and to keep the left side of your Book void, that you may write all the Passages of the Voyage; that is to say, when you set Sail, with what Wind, and what Ships are in Company, and how far you keep Company, what Storms, and how the Wind was: And likewise put down the time that you come by any misfortune, of cracking or breaking a Mast or Yard, or what Damage you receive by any Storm, and the like Occurences, as you shall think requisite: And what Currents and Variation you meet with, or if any Men should die. But before all this put down the Title of the Voyage, over the left-hand Page, in these or such like words, *viz.*

A Journal *of our intended* Voyage *by God's Assistance from* Kingrode *near* Bristol, *in Lat.* 51 *d.* 30 *m. to Madera, in Lat.* 32 *d.* 10. *m. and from thence to* Barbadoes, *Lat.* 13 *d.* 10 *m.*

The right side of your Book throughout may be divided into 13 Columns, by Lines, as you may see in the following Examp. In the 1st must be expressed the Day of the Month. In the 2d, the Letters of the Week-days that Year. In the 3d Column the Months; make it large enough to put down the Lat. you make by Observation of the Sun or Stars, and Currents how they set. In the 4th, the Course steered by the Compass. In the 5th, the Variation of the Compass, if there be any. Set down the Angle that the Rhomb maketh with the Merid. in the 6th Column: And in the 7th, the Dist. sailed in Leagues or Miles. In the 8th, 9th, 10th, and 11th Columns, set down the Northing, Southing, Easting and Westing. In the 12th, the Lat. by Dead Reckoning. And in the thirteenth Column, the difference of Longitude from the first Meridian, according to *Mercator's* Chart.

Let this be your Examp. We will frame a Reckoning between the 3 places before-mentioned, from *Lundy* to *Madera*, from thence to *Barbadoes*, whose dist. in their Rhombs and diff. of Lat. and Merid. dist. I have put over in the Head of the Columns in the left hand Page.

You see by the left hand Page that we set sail the 25th day; but we entered it not in the right hand Page until the 26th day at Noon: for it is to be understood, that since her setting sail *March* 25 to Noon of the 26th day, the Ship steers away and makes her way good on the S. b. W. $\frac{1}{4}$ W. Point of the Compass; but the Variation being 5 deg. $\frac{1}{2}$ or half a Point to the Eastward, as you see in the 5th Column, therefore the Point she hath made good upon is only S. W. 22 deg. 20 min. as is expressed in the 6th Column: Upon this Rhomb she sails 48 Leagues, as in the seventh Column appears:, And answerable thereunto I find in the Traverse-Table before-going, the Southing to be 44$\frac{35}{100}$ Leagues, or by the Traverse-Scale 44$\frac{4}{10}$ Leagues; and the Westing 18$\frac{37}{100}$ Leagues, by the Traverse-Scale 18$\frac{4}{10}$ Leagues, as here in the ninth and eleventh Column appears.

The Figures to the left signifie Leagues in this *Journal*, and the 2 Figures to the right hand signifie the 100 part of a League. The Southing being 44$\frac{35}{100}$ Leagues, which is 2 d. 13 m. nearest; if that be subtracted from the Lat. from whence you came, *Lundy* 51 d. 20 m. it makes the Lat. the Ship is in at Noon, to be 49 d. 7 m. as appears in the 12th Column. In the same manner, in the next line, being the 27th of *March*, sheweth, that from the 26th day at Noon, to the 27th day at Noon, she made her way good upon the S. b. W. $\frac{1}{4}$ W. Point of the Compass; but the Variation being 5 d. $\frac{1}{2}$ Easterly, therefore the Angle of the Rhomb which the true Merid. was S. W. 22 d. 30 m. and sailing 49 Leagues, the Southing is 45$\frac{27}{100}$ Leagues; and the Westing 18$\frac{75}{100}$ Leagues: So the Latitude is now 46 deg. 51 min.

To

To find the Longitude in the last Column, convert the Easting and Westing, that is, the Leagues in the East and West Column, into Degrees and Minutes of Longitude, by this Rule, which is near the Truth, provided these Rhombs differ not much one from another, by which Rule I found the Longitude for every Sum in the *Journal*.

Say then, As the difference of Latitude, to the Departure from the Meridian:

So is the Diff. of Lat. in Meridional Parts or Leagues, to the Diff. of Long. in Leagues.

The Difference of Lat. in the South Column sum'd up (as you must do as often as you have any notable Difference betwixt your observed Lat. an Dead-Lat.) is 1367$\frac{4}{10}$ Leagues; omit the last Figure to the right hand, *viz.* $\frac{4}{10}$, and then it will be 136 $\frac{7}{10}$.

The Depart. from the Merid. in the West Column is 56.64; omit the last Figure, it is 566. So you put them down.

The Meridional parts for the Latitude 51 deg. 22 min. is ——— 12002
The Meridional parts for the Latitude 44 deg. 30 min. is ——— 9959
The Difference of Latitude in Meridional parts is ——— 2043
Say then, as the Sum of the South Column, or Diff. of Lat. 1367 ——— 313576
Is to the Sum of the West, or Depart. from the Merid. 566 ——— 275281
So is the Difference of Latitude in Meridional parts 2043 ——— 331026
606307
To the Difference of Longitude in Leagues 84$\frac{4}{10}$ ——— 292731

Which reduced into *Degrees* is 4 deg. 14 min. for the 28th of *March*.

But let us proceed with our *Journal*. I observed the Meridian Altitude of the Sun the 31 day at Noon. I find my Latitude by Observation 38 deg. 30 min. which, by Dead-Reckoning it, is 38 deg. 38 min. so the Difference is 8 min. Southerly; but being assured of a good Observation, I correct the Dead-Reckoning thereby by this Rule of Proportion, saying,

As the Sum of the North Column 1201 ——— 3.07954
To the Sum of the East Column 520 ——— 2.71600
So is the aforesaid Increasing Southerly 27 ——— 1.43136
4.14736
To the Increasing Westerly 1$\frac{17}{100}$ Leagues ——— 1.06782

Which is 1 League $\frac{1}{10}$, and something more, not to be taken notice of.

This *Rule of Proportion*, *Norwood* hath laid down in his *Seaman's Practice*, in the Description of his Journal from *Barmudoes* or *Summer Islands* to the *Lizard*; which is thus.

Now this Difference being found, I put down in the South Column the Difference 2$\frac{78}{100}$ Leagues, and the West Column 1$\frac{18}{100}$ Leagues, and under Distance 2$\frac{8}{10}$ Leagues: Now the same corrected is by Observation 130$\frac{8}{10}$ Leagues, 120$\frac{18}{100}$ Leagues Southing and Westing 32 Leagues 8 min. subtracted from the Dead Latitude, make 38 deg, 30 min. the true corrected Latitude according to Observation.

In like manner, upon the third of *April* I should be in Latitude 32 deg. 19 min. but by very good Observation, I find the Ship in the Latitude 32 deg. 30 min. that is, not so much Southerly by 11 minutes: therefore to correct it by Observation, I put under Distance 3$\frac{8}{10}$ Leagues, and in the North Column 3$\frac{66}{100}$ Leagues, and in the East 1$\frac{18}{100}$ Leagues, and under Dead Latitude 11 minutes: I subtract the corrected Difference of Distance out of the Sum over it, and likewise the corrected Difference in the North Column out of the Sum in the South, and likewise the East out of the West Column, and add the 11 min. to the Dead Latitude, and then you have the Sum corrected: but if there be any Current, you may set it down, and allow for it, and note it down, as is that Example following the first of *April* to the third, and by your Traverse-Scale presently find how much the Current hath set you to the Eastward.

But if your Course be near the East and West, it is sufficient to correct it in Latitude only, as in the Example of the 12th and 13th of *May*; for in that Case the Longitude cannot be corrected but from some further ground. Now to set down this Reckoning upon the Plain Chart, or common Sea-Chart, every day, it is needless: The better way is to set down every one of the Sums as they are corrected by Observation, in the same manner as you are directed in the latter end of the third Chapter of this Book; and so by the total Sums of the Diff. of Lat. and Dep. from the first Meridian, you may set it down on your Chart as often as you please. But if you are desirous to set down your Reckoning in a *Mercator* or *Wright*'s Chart, you have in the 12th and 13th, or last two Columns of your Journal the substance and principal scope of your Reckoning: set down as often as you sum up or correct your Reckoning: namely, your Lat. and Long. which whensoever you have a desire to set down in the foresaid Chart, or any other graduated Chart, with deg. of Long. and Lat. you may readily do it.

In sailing E. and W. you have a Rule in Prob. 7. of Sailing by Mercator *or* Wright*'s Chart.*

For Example. Suppose I would set down the place on the Chart where the Ship is, from the 25th of *March* to the 13th of *May*, I find the Lat. against the 25th of *March* 51 d. 20 m. and the Lat. of the *Barbadoes* 13 d. 10 m. and the Diff. of Long. 52 d. 35 m. Therefore in the Lat. of 13 d. 10 m. I draw or point out an occult Parallel, and reckon 52 d. 35 m. from the Island of *Lundy* towards the West: I draw by that Long. an occult Meridian; the Intersection of this Meridian with the foresaid Parallel is the Point representing *Barbadoes*, or the Place of the Ship: and the like is to be understood of any of the other. And so I put down in the General Chart of *Mercator* the 8 Points of the Ships Place, 1 a, 2 b, 3 c, 4 d, 5 e, 6 f, 7 g, 8 h, as there you may see.

A

1696	Month Days.	Week Days.	*A Journal of our Intended Voyage, by Gods Assistance in the Good Ship the* Eliz. *of* B. S. S. *Commander, from* Kingrode, *in Latitude* 51 d. 30 m. *to* Madera *in Latitude* 32 d. 30 m. *and from thence to* Barbadoes, *in Latitude* 13 d. 10 m.
March	25	a	Set sail out of *Kingroad*, in Company with the *John* bound to *Cales*, and *Anne* bound to *Virginia*; the Wind at *E. N. E.* thick rainy Weather.

The Journal of our Intended Voyage, by God's Assistance, in the *E* of *B. S. S.* Commander, from *Lundy*, in Latitude 51 *d.* 20 *m.* to the Island of *Madera*, in Latitude 32 *d.* 30 *m.* Course S. S, W. 1 *d.* and half West. Distance 411 Leagues, Meridian Distance 167 Leagues, Difference of Longitude 11 *d.* 16 *m.* from *Madera* to *Barbadoes*, in Latitude 13 *d.* 10 *m.* Course S. W. 61 *d.* 14 *m.* Distance 798 Leagues, Meridian Distance 698 Leag. Difference of Longitude 41 *d.* 40 *m.*

			Course SSW SWbWhalfW	East Variation.	Deg. from the Merid. SW 25 d. SW 61 d. 14 m.	Dist. 411 798	Di.La. 377 387 le	Dif.Lat. 377 387 lea.	Dep. 167 698	Dep. 167 698	51d.20' 32d.30' 13d.10'	Diff.Lo. 11d.16' 41d.40'
		Latitude by Observation.	Course by Compass	Variation of Compass.	Degrees from the Meridian.	Dist. sailed.	North	South.	East.	West	Lat. by dead R.	Diff. of Longit.
		Deg. Min.	Points.	Degrees	Degrees	Leag.	Leag.	Leag.	Lea.	Leag.	D. M.	D. M.
26	a	Set sail March 25.	S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	48		44 35		18 37	49 07	
27	b		S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	49		45 27		18 75	46 51	
28	c	44 deg. 31 min.	S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	51		47 12		19 52	44 30	
28			Add up the Numbers the Sum is			148		136 74		56 64		04 14
29	d		S S W	2 deg. 45 min. E	S W 25 d. 15 m.	43		38 87		18 38	42 34	
30	e	40 deg. 27 min.	S S W	1 degree East	S W 22 d. 30 m.	46		42 50		17 60	40 26	
31	f	38 deg. 30 min.	S S W	0 degree East	S W 22 d. 30 m.	39		36 03		14 92	38 28	
			Add up the Numbers, the sum is			128		117 40		50 90		
			Correction by Observation			2 9		2 70		01 10	8	
			The sum corrected is			130 9		120 10		52 00	38 30	07 43
			Difference of Latitude, Depart. from first Merid.			278		256 84		108 64		
1	G	April, a Current	S W b S	11 d. 30 m. Cur.	S W 22d. 30m	43		43 42		17 99	36 17	
2	a	sets E. by S.	S W b S	11 d. 30 m. Cur.	S W 22d. 30m.	45		41 57		17 22	34 12	
3	b	32 deg. 30 min.	S W b S	11 d. 30 m. Cur.	S W 22d. 30m.	42		38 80		16 07	32 19	
		Set to the Eastward by the Current is 3 days, 22	Add up the Numbers, the Sum is			134		123 79		51 28		
			Correction by Observation			3 9	3 66				11	
			The sum corrected is			131		120 13	1 50	49 78	32 30	10 46
4	c	Leag. and almost half E. b S. by esti.	Madera Island bears West distant			8.58				8 58		
			Difference of Latit. Depar. from the first Merid.			418		376 97		167 00	32 30	11 16
24	b	Set sail April 23. from Madera.	S W by S	5 d. 30 m. East by Current.	S W 28 d. 30 m.	36		31 75		16 97	30 55	
25	c		S W by S	2 d. 45 m. East	S W 30 d. 45 m.	46		39 46		23 65	28 57	
26	d	27 deg. 43 min.	S W by S		S W 33 d. 45 m.	30		24 94		16 67	27 42	
27	e	25 deg. 54 min.	S W		S W 45 deg.	51		36 06		36 06	25 55	
28	f	23 deg. 47 min.	S W		S W 45 deg.	60		42 43		42 43	23 48	
29	G	22 deg. 40 min.	S W		S W 45 deg.	28		19 80		19 80	22 47	
			Numbers added, the Sum is			134		194 44		155 58		
			Correction by Observation			3		2 30		1 90	7	
			Sum corrected is			154		196 74		157 48	22 40	
29			Difference of Lat. and Depart. from first Merid.			572		573 71		324 48		20 47
30	a		S W b W	00 degr.	S W 56 d. 15m.	45		25 00		37 42	21 25	
1	b	May	S W b W	00 degr.	S W 56 d. 15m.	47		26 11		39 08	20 07	
2	c	18 deg. 57 min.	S W b W	00 degr.	S W 56 d. 15m.	43		23 89		35 75	18 56	
3	d		S W b W	00 degr.	S W 56 d. 15m.	44		24 44		36 58	17 43	
	e	16 deg. 50 min.	S W b W	00 degr.	S W 56 d, 15m.	39		21 67		32 43	16 37	
			Add up the Numbers, the sum is			218		121 11		181 26		
			Correction by Observation			7 8	4 33		6 50		13	
			Sum corrected is			210 2		116 78		174 76	16 50	
4			Difference of Latit. Depart. from first Merid.			782 2		690 49		499 24		31 06
5	f	16 deg. 14 min.	W S W half W	5 degr.	W S W 67 d. 30 m.	51		11 86		26 64	16 15	
6	G	15 deg. 03 min.	W S W half W	5 d. 30 m.	W S W 67 d. 30 m.	46		17 60		42 50	15 22	
7	a		W S W half W	5 d. 30 m.	W S W 67 d. 30 m.	33		12 63		30 49	14 44	
8	b	14 deg. 03 min	W S W half W	5 d. 30 m.	W S W 67 d. 30 m.	30		11 48		27 72	14 09	
			Add up the Numbers, the Sum is			140		53 57		127 35		
			Correction by Observation			5 2		2 00		4 80	13	
			Sum corrected is			145 2		55 57		132 15	14 03	
8			Difference of Latit. Depart. from first Merid.			927 4		146 6		631 39		38 50
9	c	13 deg. 48 min.	W b S half W	5 deg. half	S W 84 d. 20 m.	55		5 39		54 73	13 47	
10	d		W b S half W	2 deg. 50 m.	S W 87 d. 11 m.	60		2 94		59 92	13 39	
11	e	13 deg. 10 min.	W b S half W	00 deg. 00 m.	S W 78 d. 30 m.	51		9 95		50 02	13 09	
		Ship's in Lat. Bar-	Add up the Numbers, the Sum is			166		18 28		164 67		
11		badoes 69 lea. E.	Difference of Latit. Depart. from first Merid.			1092		164 34		796 06		48 41
12	f	13 deg. 00 min.	West	5 d. 30 Cur. sets	S W 84 d. 22 m	39		3 80		38 60	12 59	
13		The Current set S	W by N	S 2 d. 45 m Cur.	S W 81 d. 30 m.	26	81			25 71	13 10	
13	G	13 deg. 11 min.	Difference of Latit. Depart. from Lundy			1163		764 33		860 37	13 10	52 39
13			Barbadoes Island bears West distant of Leag.			5						

A TABLE of the Longitude and Latitude of the most Notable Ports, Harbours, Capes, Islands, and Head-Lands in the WORLD.

Beginning the Longitude at the Meridian of the *Lizard*.

Coast of New-found-land, *and* New-England.

The Places Names.	*North Latit.* D.	M.	*West Longit.* D.	M.
Cape Hambleton	52	11	50	14
Bell-Isle	51	02	48	44
Cape Bonavista	49	19	47	42
Trinity *Bay.*	48	54	49	04
Bacalao *Island*	48	40	46	55
Consumption *Bay*	48	21	47	49
Cape St. Francis	48	01	47	27
Cape Despair	47	36	46	03
Cape Race	46	27	46	30
Bay Bulls	47	28	47	11
St. John's *Harbour*	47	47	47	21
Plasentia *Bay*	47	32	47	41
Cape St. Larinso	47	10	48	59
Cape Roy	48	05	52	49
Cape Britain	46	01	52	57
Cape Sable	43	46	55	22
Cape Codd	42	21	61	32
Boston	42	39	64	36
Plymouth	42	07	62	35
Nantucket	41	08	60	17
Martins Vinyard	41	17	61	12
The Sea-Coasts on the main Continent in* America, *or West-India.				
Elizabeth Island	41	02	62	04
Block Island	40	55	62	36
Long Island	40	45	63	16
Cape May	39	10	64	45
Virgina. Cape Charles	37	20	65	26
Cape Henry	37	00	65	38
Cape Haterass	35	32	65	46
Cape Fear	34	06	69	56
Cape Florida	24	40		
Cape Catocha	14	30	70	56
Cartagena	10	34	65	06
Cape 3 Points	10	47	55	41
Cape Breme	08	20	54	16
Suranam	05	38	49	52
North Cape	1	10		
The West-India Islands.				
Burmudos	32	25	56	00
Bahama	27	57	73	06
Sigvatro	26	18	68	45
Guatro	25	47	68	00
Guamina	25	15	67	53
Tiango	24	33	66	30
Guanahimo	23	50	66	39
Caycoss	22	05	64	31
Amiana	21	40	64	38
Hinagua	21	19	67	03
Yamatta	22	32	67	49
Soamia	24	20	68	50
Yamia	24	22	70	10

The Places Names.	*North Latit.* D.	M.	*West Longit.* D.	M.
St. John de Portarica	18	30	60	42
Santa Cruce	17	42	59	18
Anguilla	18	28	57	00
St. Martin	18	15	56	47
St. Bartholomew	18	05	56	33
Barbuda	17	18	55	33
Antegoa	16	32	54	38
Desseada	16	10	54	36
Maragallanta	15	41	55	26
Dominica	15	00	55	05
Martineco	14	30	54	44
St. Lucia	13	30	54	43
Barbadoes	13	00	52	58
Tabago	11	10	53	06
Gianada	12	10	54	31
St. Vincent	12	50	54	18
Guardalupa	16	00	55	31
Monsarat	16	20	55	41
Mevis	16	50	56	27
St. Christophers	17	10	56	45
Island Devas	15	57	57	28
Island Blanco	12	20	56	51
Turtuga	11	30	57	40
Island Derickilla	12	19	58	01
Roca	12	19	58	53
Island Deavos	12	29	59	22
Bonoga	12	32	60	54
Querissa	12	25	60	39
Moagos	12	20	61	55
East end of Hispaniola	18	27	62	28
Middle of Hispaniola	18	30	64	58
West end of Hispaniola	18	25	68	26
East end of Jamaica	18	00	71	58
Jamaica Harbour	18	05	72	57
West end of Jamaica	18	38	74	57
The East end of Cuba	20	10	75	56
Caimanis	19	41	77	41
Grand Caiman	19	21	78	45
Santavilla	17	28	77	50
Mosquito	14	50	76	04
Guanabo	16	33	81	19
Guanabimo	16	10	83	04
Cozumal	19	25	84	56
Lasalleeranas	22	00	87	58
The Island Delas	23	30	91	58
Labarmaia	22	55	93	16
Island Dearanas	22	36	93	14
Triango	21	23	93	05
The Island of Prondanco	13	27	81	16
St. Andrea.	12	42	80	57

The

The Sea-Coasts of Brazilia.

The Places Names.	South Latit. D.	M.	West Longit. D.	M.
The River Amazons	00	00	41	30
The Island of Ascension	07	48	20	06
Cape Blanco	02	25	22	29
Island Fernando	03	40	15	16
Abratho	05	00	17	56
Cape St. Raphali	06	10	19	36
Cape St. Augustin	08	25	18	28
River St. Miguel	09	30	19	01
The River Roal	11	21	20	41
River Gianda	14	49	22	06
Cape de Abeotho	17	52	21	42
St. Harbara	18	11	21	06
Island Ascension	17	19	17	01
Trinidada	19	50	14	24
St. Maria Dagasta	19	38	12	14
Island de Martin	19	00	08	03
Island de Pidos	21	52	05	51
Cape St. Toma	21	47	23	38
Cape Frio	22	52	24	43
Cape St. Maria	35	00	37	11
River de Plate	35	50	45	52
The Streights of Magellane	53	30	56	30
Cape de Sancto Spirito	52	20	58	30
Cape Victoria	52	30	65	40
Lima Cape	12	00	80	30
Cape Guya, Cape Blanco	06	10	85	30
Cape St. Francisco	01	30	80	30
Cape St. Frances	*North*		*West*	
Point de bon Matre	07	30	80	00
Nombre de Dios W. Sea	10	00	77	30
Nova Albion in the S. Sea	46	00	162	30
Cape de Fortuna	55	30	170 *E*.	0
Tapan Insule	36 *N*.	00	153 *E*.	0
Cape de Beuena Desco	01 *S*.	00	155	00

Islands in the East Indies.

The Places Names.	South Latit. D.	M.	East Longit. D.	M.
Hipon Island	06	45	115	20
Batam on Java	06	15	125	34
Jambe	01	49	125	25
South end of Sumara	05	52	125	48
Middle of Sumatra	01	30	120	49
North end of Sumatra	05	28	116	35
Gomaspala	05	40	116	29
Island Desombro	08	00	114	44
Island Rusta	09	50	114	33
Quarinibar	11	10	114	44
Island Dandemajo	13	00	114	39
Island Decocos	14	30	115	12
Celloan	07	50	98	39
Doda Safia	09	40	93	02
Garine	10	50	90	56

The Places Names.	North Latit. D.	M.	West Longit. D.	M.
Moique	09	05	91	29
Island de Profol	10	23	90	55
Island de Zocha	11	12	90	45
Chorebaman	12	32	87	55
Sucatra	12	18	74	01
Apoluaria	09 *S*.	20	90	50
Degomo	02	40	87	35
Piedros Blancho	06	10	76	55
Diego Gratiosa	08	30	78	15
Domes Caicuhas	03	21	65	24
Island Quellallo	03	40	64	20
De Almiranta	03	57	63	28
Agnalaga	09	00	66	15
Asdore Has	09	05	65	02
John de Nova	09	00	63	26
Cosmobodo	09	40	61	52
Donatall	08	20	59	57
Aignos	09	30	58	18
John de Comoro	09	00	57	20
Zanziba	06	26	53	35
Manfia	07	50	53	08
John Demiz	10	48	54	24
Comoro	11	20	55	48
Mayatta	12	40	57	55
St. Christopher	14	30	56	03
John de Nova	17	20	55	29
Bassas de India	22	10	55	23
N. end of St. Laurence	25	37	60	54
St. Apohima	20	50	65	54
Domscaicahas	20	50	66	54
Monritius	20	10	68	44
Dosgarias	15	20	70	43
Englands Forest	20	50	74	14
Diego Raize	20	05	75	54
John de Lisbone	25	24	68	32
Romoras	28	19	81	21

The Sea-coast on the Main Continent in the East India.

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Malacca	01	41	116	14
Queda	06	47	117	44
River de Care	10	45	118	54
River Bengale	22	09	121	33
Aicopoir	20	19	112	39
Samnabron	18	30	108	52
Arme Gon	14	35	100	27
Cape Comorin	07	50	97	39
Cochin	09	40	97	29
Callant	10	48	97	27
Mongalar	12	40	97	19
Goa	14	40	97	01
Chaul	18	10	98	51
Calecut in East India	11	30	92	58

Macao

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Macao in the K. of Pegu	19	30	112	49
Domon	11	54	99	01
Surrat	21	00	99	36
Dio	20	48	96	57
River Decinda	24	55	95	39
Cape Mucoaridan	25	32	82	39
Cape Russalgat	22	07	84	39
Cape de Ponto	18	19	79	09
Cape de Matraia	15	33	72	39
Adon	13	08	66	56
Cape Guardafuy	11	40	71	24
Cape de Bassos	04	30	65	19
Magadox	02	30	59	24
Molinda	02 S.	42	52	11
Cape Fassto	08	02	52	24
Cape Corintes	23	30	48	51
Cape St. Marin	25	40	46	59
River St. Lustea	28	25	46	09

The Sea-Coast from Cape Bone Esparanca *to* Guinea.

The Places Names.	*South Latit.* D.	M.	*East Longit.* D.	M.
Island Desistian	36	57	11	44
Island Degiaiattica	37	56	14	04
Cape Agullas	36	20	33	54
Cape Bona Esparanca	34	25	32	54
Cape Sacos	29	40	30	14
Ascension Island	07	48	05	24
St. Helena	16	00	19	06
St. Helena Nova	16	00	19	48
Bassas	17	45	27	35
Cape Lado	10	00	29	23
Cape Padron	06	00	29	04
Cape Lopas	01	00	25	21
Anabona Island	01	22	22	56
Island St. Matheos	01	40	07	45
Island St. Toma	00 N.	10	23	34
Island Cacos	00	40	23	50
River Gaboan	00	10	27	16
River de Angai	01	00	27	30
Island de Principas	01	50	25	14
Island Defarnando	03	10	26	06
River Boilin	02	42	27	29
River Decainaronas	04	00	27	09

Sea-Coast from Sampson's *River to the River of* Gambo, *Coast* Guiney *and* Barbary.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Old Callabar	04	50	25	15
New Callabar	04	40	23	37
Cape Formossus	04	03	22	52
River Binnin	06	50	22	12
River Dallagoa	07	40	19	49
River de Valta	06	05	16	52
Cape 3 Points	04	10	13	10
River St. Andras	05	23	08	06
Cape de Palmas	04	30	06	05
Cape Mounta	05	23	01	46
Cape Roxo	11	38	06W.	13
River of Gamboa	12	47	02	17
Cape de Verd	14	24	06	57

The Cape de Verd Islands.

The Places Names.	*North Latit.* D.	M.	*West Longit.* D.	M.
Abrolho	00	00	16	16
Vigia	03	01	10	10
St. Paul	01	32	14	56
Rocafs	02	30	16	16
Varo	11	12	12	07
Vigia	12	26	19	48
Abrogo	16	36	10	19
Brava	14	49	15	14
Fogo	14	42	14	56
Santiago	14	52	14	22
May	15	00	14	02
Bonavista	15	58	13	49
Sall	17	00	13	36
St. Nicholas	16	30	15	44
St. Lucia	16	50	16	08
St. Antonio	17	07	16	56
Cape Blanco	20	30	09	26
Cape Denao	28	52	01	46
Cape Gillam	29	50	01	29
Cape de Gere	30	00	01	25
Cape Cantin	32	17	01	06
Sally	34	40	09	48
Tangire *East Longitude*	35	36	01	49

The Sea-Coasts on the Main, from Tangire *to* Joppa *in the* Straits.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Ballis	34	57	03	48
Oran	35	46	07	59
Tunis	36	30	09	18
Argier	36	40	10	54
Gion	36	50	13	30
Colla	37	09	15	14
Bona	37	19	16	44
Tunis	36	50	17	24
Cape Beun	37	05	18	11
Britto	35	23	18	41
Cherunne	34	56	18	36
Cape Mizarrata	32	18	24	00

Cape

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Cape de Solli	31	1	25	49
Cape Ruſſutta	32	58	29	26
Cape Roattini	32	18	32	04
Alexandria	30	40	41	28
Michallat	30	30	41	55
Cairo	30	35	41	44
Joppa	31	42	43	39

The Coaſt from Antiochia *to* Sagua.

Antiochia	34	54	46	26
Cape Pollopolla	35	35	44	01
Cape Seridioni	35	55	41	24
Cape Decoxman	36	16	36	44
Cape Babarnau	37	58	36	22
Incommodio	40	26	40	39
Conſtantinople	40	56	40	33
Gallippolo	40	20	37	59
Cape Degriſſa	40	12	37	11
Cape Pimra	40	26	32	23
Cape St. George	39	28	32	10
Cape Collo	37	40	32	35
Cape Sille	37	15	31	52
Cape Matapan	36	28	30	53
Cape Linga	40	18	29	38
Hiraſſa	40	57	30	38
Cattaro	42	21	29	47
Raguſſa	42	29	28	57
Stanio	42	57	28	11
Trovor	43	30	27	37
Cape Caſta	43	27	26	48
Zaro	44	05	26	39
Sagua	44	47	25	49

From Venice *to* Gibraltor.

Venice	45	37	22	45
Gorro	44	57	21	35
Ancana	43	25	24	29
Angollo	41	31	27	02
Cape St. Maſſa	39	52	26	53
Gallipoli	40	08	27	04
Cape Callom	38	50	25	40
Cape Sparta-ventura	37	46	24	16
Sallarno	40	51	23	32
Napolis	41	08	22	51
Rome	41	50	21	09
Ciritacha	41	46	20	24
Leagorne	43	28	19	03
Cape Melle	43	51	15	37
Cape Larci	42	58	14	38
Tollone	43	00	14	04
Marſilia	43	12	12	44
Cape Degofrito	41	41	11	18
Cape Pallos	40	10	08	39
Cape Martin	38	46	08	20
Alicant	38	20	07	14

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Cape Paul	37	28	07	11
Cape de Gat	36	47	05	24
Veliz	36	49	03	33
Malaga	36	45	03	07
Gibraltor	36	40	02	06

The Iſlands in the Archipelago.

Sarfanto	36	57	33	39
Sarfo	37	17	33	22
Famania	37	28	33	18
Pipor	39	32	33	51
Laſſor	39	58	33	51
Lamo	39	44	33	38
Stripo	39	16	33	51
St. Penaga	38	52	33	03
Andrea	38	12	34	46
Ipſava	38	28	35	11
Mortalin	39	54	35	52
Staviſratta	39	28	35	14
Lamnos	39	41	35	49
Palamos	40	14	36	04
Toſſa	40	00	35	19

Iſlands in the Straits.

Sapientia	36	47	30	16
Zant	37	37	29	38
Cape Sidro	38	15	29	33
Paxa	38	49	29	30
Corfu	39	26	29	26
Seſſino	40	22	29	14
Pianaſſa	41	52	26	08
Trinite	41	50	25	53
Mallida	42	37	28	03
Auguſta	42	36	27	13
Catſſo	42	44	26	58
Liſſa	43	00	26	33
Buzo	43	02	26	18
St Androa	43	07	25	58
Iſland Groſſo	44	00	25	36
Sauſſaga	44	20	25	02
Piper	35	52	22	15
Malta	36	00	21	54
Comino	36	15	21	24
Eaſt end of Cyprus	34	48	44	18
Middle of Cyprus	34	18	43	09
Weſt end of Cyprus	34	22	41	47
Rhodes	35	40	37	22
Gozo	34	37	32	39
Eaſt end of Candia	35	04	35	32
Middle of Candia	35	08	33	56
Weſt end of Candia	35	15	32	25
Scarpanta	45	10	36	04
Langa	36	33	36	02
Stampalia	36	11	34	59
Niza	37	02	34	31

The Places Names.	North Latit. D.	North Latit. M.	East Longit. D.	East Longit. M.
Cavari	36	40	32	16
Palla	36	52	32	09
Cardinals	37	25	32	31
Millo	36	40	33	19
Goza	35	41	20	51
Lampadossa	35	58	19	59
Linossa	36	20	20	05
Kambro	37	10	18	34
Maritimo	37	52	20	02
Massina	38	07	23	21
East end of Cicilia	37	07	23	24
West end of Cicilia	37	52	20	07
Ustica	38	50	20	58
Fallieur	38	43	22	01
Lipari	38	40	22	27
Stromballa	39	03	23	02
Foldemassina	38	20	23	29
Iscia	40	46	21	36
Palmarolla	40	50	19	59
Ginnute	41	59	19	48
Crista	41	55	18	51
Lilbo	42	31	18	36
Caprera	42	48	18	21
Gargona	43	20	18	28
North end of Corsica	42	55	17	26
South end of Corsica	41	20	17	01
Taloro	40	56	17	19
Azanera	41	08	16	22
North end of Sardinia	41	10	17	25
South of Sardinia	38	56	16	37
The Island of St. Pedra	39	20	16	03
Sarpentara	39	00	17	18
Callatta	37	57	16	28
Minork	39	55	12	16
Mayork	39	38	11	12
Cabrea	39	07	11	05
Collombratta	39	50	08	44
Evisa	39	05	09	57
Formentara	38	44	09	54

The Canary Islands.

The Places Names.	North Latit. D.	North Latit. M.	West Longit. D.	West Longit. M.
Forta Ventura	28	12	06	28
Sanslorotta	28	51	06	08
Grand Canary	27	43	08	31
Tenariff	28	20	09	28
Gomara	28	09	10	15
Faro	28	05	10	43
Palma	28	58	10	42
Salvagas	30	05	08	57
Dazarts	32	08	09	46
Madara	32	27	11	19
Porta Sauto	33	14	10	09

The Western Islands.

Abraoso	37	55	29	46
Vaso	40	30	27	28

The Places Names.	North Latit. D.	North Latit. M.	West Longit. D.	West Longit. M.
Carvo	40	09	24	59
Flores	39	30	24	55
Fiall	38	49	22	13
Pico	38	30	21	37
St. George	39	00	21	20
Tessara	39	31	20	22
Gratiassa	39	30	21	11
Vajo	38	43	18	23
St. Michael	38	00	18	16
Horningo	37	25	17	36
St. Maria	37	00	17	55
Vejo	42	22	18	56
Island Varda	44	48	22	46

The Sea-coast of Portugal *and* France, *from* Cadiz *to* Callis.

The Places Names.	North Latit. D.	North Latit. M.	East Longit. D.	East Longit. M.
Cadiz	36	32	1	24
Cape St. Maria	36	52	0	W.24
Cape St. Vincent	37	00	1	18
Lisbon	39	08	1	06
Rock of Lisbon	39	00	2	04
Burlings	39	43	2	08
Isles of Boyon	42	22	2	00
Cape Finistere	43	10	2	55
Cape Corian	43	21	2	56
Cape Ortingal	44	08	0	06
Cape Pinas	44	04	0	E.52
St. Andrea	43	41	2	36
Bilboa	43	41	3	20
St. Sebastian	43	40	4	19
Burdeux	45	10	5	E.44
Rochel	46	17	4	54
Olloron	45	58	4	30
St. Martins	46	16	4	29
Use	46	44	3	20
Nants	47	45	4	15
Cardinals	47	27	2	24
Bell-Isle	47	19	2	14
Groy	47	35	1	54
Glannats	47	33	1	34
Pennes, or Pennemarks	47	35	1	11
Parker	48	00	0	W.01
Seames	48	04	0	E.25
Brest	48	35	0	54
Conquet	48	45	0	19
Ushant	48	48	0	05
Morlaix	48	54	1	35
St. Mallos	48	45	3	30
Jarze	49	30	3	24
Sark	49	37	3	09
Guernsey	49	43	2	48
Arme	49	48	3	05
Caskats	50	07	3	09
Alderny	50	02	3	37
Cape Hague	50	04	3	51

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Cape Barfleur	49	57	4	32
Seine Head	50	04	5	28
St. Vallary	50	08	5	29
Deip	50	15	6	39
Callis	51	13	7	16

Coast of England *from* Lizard *to* Newcastle.

The Lizard	50	10	00	00
Falmouth	50	22	00	12
Foy	50	35	00	34
Ramhead	50	34	00	49
Plymouth	50	36	00	51
The Ediſtone	50	22	00	44
The Start	50	27	01	19
Dartmouth	50	37	01	28
Torbay	50	42	01	36
Portland	50	50	02	36
Iſle of Wight	50	58	04	08
Portſmouth	51	08	04	24
Beache	50	58	05	15
Dongeneſs	51	09	06	15
The South Foreland	51	22	06	44
North Foreland	51	28	06	44
Harwich	52	11	06	27
Orfordneſs	52	20	06	35
Yarmouth	52	45	06	42
Winterton	52	52	06	46
Lin	52	58	05	33
The Sporne	53	45	05	01
Flamborough Head	54	08	04	35
Newcaſtle	54	58	03	14

The Coast of Scotland.

Berwick	55	49	2	39
Leith	56	03	2	09
Dondee	56	26	2	17
Aberdeen	57	22	2	29
Bokoneſs	57	48	1	34
Cat Neſs	58	37	1	38
Iſles of Orkney	58	50	2	02
Fair Iſle	59	30	3	19
Shetland	60	22	2	54
Iland Lewes	58	30	2	48
Skey Iſland	57	40	2	03

Sea-Coast of Flanders *and* Holland *from* Callis *to the* Scaw.

Dunkirk	51	[illegible]	07	49
Oſtend	51	30	08	29
Sluice	51	38	09	11
Zealand	51	48	09	05
The Brill	52	08	09	08
The Texel	53	20	10	16
The Uly	53	30	10	12
Skelling	53	35	10	14
Hambrough	54	04	13	26
Holy Iſland	54	30		
The Scaw	57	52	13	51

Sea-Coasts from the Lizard *to* Holy-Head.

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Lands-end	50	20	0	34
Gulfe	50	11	1	22
Silly	50	07	1	21
7 Stones	50	18	1	16
Harty Point	51	10	0	E. 19
Londy	51	20	0	W. 03
Holms	51	26	1	E. 44
Briſtol	51	29	2	34
Milford	52	05	0	W. 06
Holy-Head	53	44	0	26
Iſle of Man	54	25	0	36

The Sea-Coast of Ireland.

The Places Names.	North Latit. D.	M.	West Longit. D.	M.
Dublin	53	32	1	56
Waterford	52	30	2	24
Cork	42	01	2	56
Kingſail	51	52	3	08
Old Head	51	40	3	14
Mizan Head	51	28	5	21
Cow and Calf	51	42	5	42
Blaſques	52	15	6	11
Lopas Head	52	44	5	41
Gally Head	53	20	5	36
Galloway	43	40	5	16
Iſles of Aion	53	21	6	36
Slages	54	27	6	21
Iſles of Are	55	18	5	36
Fore Head	55	38	4	56
Fair Foreland	55	35	2	36

52:36
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The Sea-Coast of Iſeland Iſland.

Mage Naſs	61	32	02	51
Merchand Foreland	63	52	11	42
Horn	63	42	10	16
Silly	64	50	09	56
Bargaſar Point	65	27	07	01
Long Naſs	66	26	07	36
Rage Point	66	40	12	00
Fair Foreland	65	40	14	53
Snow Hill	65	11	14	50
Rook Point	64	00	14	09
Weſt main Iſles	63	17	12	53
Gammat Iſles	63	48	15	06
Grimes Hole	63	23	15	46

The Sea Coast in the Sound.

The Places Names.	North Latit. D.	M.	East Longit. D.	M.
Elſen-nore	56	40	15	21
Copenhaven	56	17	15	18
Iſmond	55	20	16	44
Burntholm	56	00	17	40
Erthholm	55	10	17	38

Farro

The Places Names.	North Latit. D.	North Latit. M.	East Longit. D.	East Longit. M.
Farro Sound	58	48	21	53
Gotland	58	20	21	22
Dormamel	56	55	23	44
Dines Naſs	58	22	23	55
Riga	57	50	26	25
Runen	58	38	25	14
Shorham	58	58	26	30
Ardenbro	59	05	24	06
Dagaratt	59	44	23	55
Ogſholm	59	58	24	32
Eaſt Rand	60	12	28	41
Wibrough	61	16	30	00
Patting	61	00	28	45
Roſtbrugh	61	03	25	04
Abbo	61	08	23	28
Stockholm	58	49	20	06
Frouenboro	58	48	18	16
Fuland	57	42	19	12
Faſtinboro	56	02	15	49
Scarlet Iſland	56	40	16	02
Elſinbrough	56	46	16	00
Cape Cole	57	00	15	36
Nading	57	53	15	04
Holm Sound	59	08	13	44
Long Sound	59	07	12	54
From Naze of Norway *to* Archangel.				
The Naze of Norway	58	00	10	26
Stave Angor	58	57	09	44
Out Shers	59	07	08	30
Bomal	59	31	09	04
Harla Iſland	60	24	09	02
Katts Neſs	61	54	08	06
Swin	62	40	09	10
Gallee	62	52	09	46
Gripo	63	40	11	26
Roſs Iſles	67	01	13	30
Lowſat	68	30	14	40
North Cape	71	22	22	06
Skitanboro	70	56	24	02
Iſland Kilding	68	54	26	16
Cape Race	65	49	29	28
Cape Gallant	67	11	28	56
Cape Grace	65	17	28	54
Fox Naze	64	12	26	31
Archangel	53	22	26	46
The Coaſt of Greenland.				
Cherri Iſland	74	34	20	31
Hope Iſland	76	13	23	16
Hopeleſs Iſles	77	00	22	54
Nageo Point	77	10	23	38
Cape Bland	78	25	23	26
Helis Sound	79	27	24	19
Point Lookout	76	25	20	18
Horn Sound	77	07	20	00
Bear Sound	79	15	19	55
Black Point	78	32	18	34
Cape Cold	79	00	17	56
Fair Foreland	79	15	19	29

The Coaſt of the North-Weſt Diſcovery.

The Places Names.	North Latit. D.	North Latit. M.	Weſt Longit. D.	Weſt Longit. M.
Cape Farewel	59	00	41	50
Sir Thomas Smith's Bay	79	10	79	50
Botton's Iſles	60	20	62	50
Bell-Iſle	51	02	48	44

Where the Table is begun, on the Coaſt of Terra-Nova.

A Deſcription of the Table of the Latitude and Longitude of Places.

THE Ancient Geographers, from *Ptolomy*'s Time downward, reckoned the Longitude of Places from the Meridian, which paſſeth through the *Caps de Verde Iſlands*; and others at the *Canary Iſlands*; and ſome at the *Iſle Pico* one of the *Azores*; and others from the Weſtermoſt part of St. *Michaels*, another of the *Azores*: Who albeit they differ greatly in reſpect of the beginning of their ſeveral Longitudes, they come all to a pretty near Agreement for their difference of Longitude from any particular Meridian or Place: And for the exact ſettling of Latitudes, we have many certain helps; but the Longitude of Meridians hath ſtill wearied the moſt Able Maſters of Geography. By Latitude and Longitude, the Geographers ſtrive to repreſent the Parts of the Earth, that they may keep Simmetry and Harmony with the whole.

The difference of Longitude between two Places, is an Arch of the Æquinoctial intercepted between the two Meridians, paſſing by thoſe Places.

The Latitude of a Place is the diſtance of the Zenith, or the Vertical Point thereof from the Æquator, or the Height of the Pole elevated above the Horizon. You have been ſhewed ſeveral ways already, for the finding the Poles elevation above the Horizon: But this Rule will not be impertinent in this place, being not named before, which is by the Stars thus, and is proper to obſerve the Latitude on the Land.

• You muſt obſerve ſome Fixed Stars in the Heavens, which is near the Pole, and that never ſets in that Region: Thus, you may obſerve the leaſt and alſo the greateſt Altitude of the ſaid Star, when he doth come to the Meridian under the Pole and alſo above the Pole; which done, you muſt add the leaſt Altitude to the greateſt, and take the half thereof, which will be the Elevation of the Pole, or Lat. of the Place. Suppoſe the firſt Star of the three in the Tail of the *Great Bear*, in his leaſt Altit. obſerved at *Briſtol*, is 10 d. 59 m. and the greateſt Altit. of the ſame, when he is above the Pole, is found to be 91 d. 59 m. (or 88 d. 1 m. from the South part of the Horizon) both which Numb. being added together, do make 102 d. 58 m. The half of that ſame is 51 d. 29 m. the Lat. or Elevat. of the Pole at *Briſtol*. I begin the Long. at the Merid. of the *Lizard*, and encreaſe it on each ſide of that Merid. from thence to 180 d. both Eaſtw. and Weſtw. therefore you muſt note, That by theſe Tables all Places that lie to the *Eaſtw.* of the Merid. of the *Lizard*, are ſaid to be in Eaſt Long. and all Places on the *W.* ſide of the Merid. of the *Lizard* in *W.* Long. Therefore a Ship being in *E.* Long. failing to the *Eaſtw.* ſhe increaſeth her Long. but ſailing to the *weſtw.* it decreaſeth. And likewiſe if a Ship be to the *weſtw.* of the *Lizard*, that is in *W.* Long. and ſaileth to the *Weſtw.* the Long. increaſeth, but ſailing to the Eaſtward, the Longitude decreaſeth.

The End of the Fourth Book.

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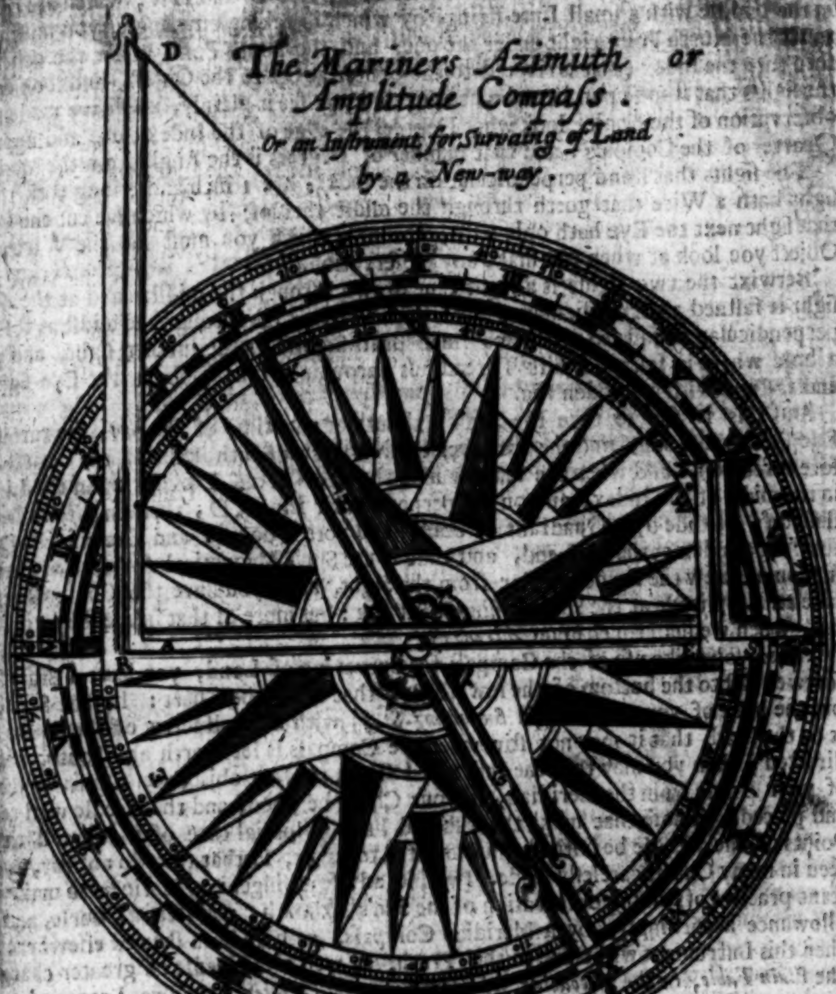
The Art of Surveying of Land by the Sea-Compass. The Description of the Compass, Staff, and Chain.

The Fifth Book.



CHAP. I.

I Have been all this while shewing the *Mariner*, How to describe and make his own *Instruments*, and the use thereof in *Navigation*; I am also willing to shew him the use there may be made of his *Sea-Compass*, commonly called the *Azimuth*, or *Amplitude-Compass*, which all ingenious *Mariners* carry to Sea.

This *Compass* requires but little Description, it being so well known to all Sea-men; for it is the same in a manner as they steer the Ship by. The *Chart* within the Box

Box is divided as you see in this Figure, each quarter into 90 Degrees, beginning at North and South, numbred East and Westward; on the Glass there is a Brass Circle and Diameter, that goes over the Center of the *Compass-Chart*, the Brass Circle may be about 7 ½ Inches Diameter, and about ¼ of an inch broad; the outward Circle is divided into 360 Degrees, by 90 Degrees in each Quarter, as the former was; the Figure makes all plain to the meanest Capacity; the inward Circle is the Hours and Quarters, and they are numbred as you see in the Figure.

In the Diameter F G H K there is a right Line drawn in the midst, as G H, and at each end is two slits of an inch and an half long, as F G and H K; which are cut right in the middle with a small Lute-string, by which in taking any Angle, you must be sure to set the North Point right under the one, and the South Point under the other, and then turn the Index (that is riveted to the Center at C) to the Object, and look through the sights that stand upon it, and when you find you see it plainly, and have made a good observation of the Angle, look what Degrees the edge of the Index cuts, and upon what Quarter of the Compass: and that number of Degrees is the Angle from the Meridian.

The sights that stand perpendicular on the Index, are 1 inch and ½ long; the further sight hath a Wire that goeth through the midst thereof, by which we cut the Object: that sight next the Eye hath only a slit, through which you must see the Wire cut the Object you look at when you make any Observation.

Betwixt the two sights is a right Line drawn through the midst, and at the further sight is fastned a perpendicular of Brass with a right Line through the midst as R D: this perpendicular is fastned with two small Brass Screws to the further sight, and at D is a hole where is fastned a Silk Thread put through a small hole in the Eye-sight at S, and fastned with a wooden Pin.

The use of the Azimuth-Compass. And this is for to take the Sun's Azimuth at any time of the day, by turning the Eye-sight to the Sun, and the Slits over the North and South Point of the Chart (as before directed), and when the shadow made by the Thread D S falls upon the Line S A in the midst of the Index, and on the perpendicular Line R D; then on that instant take the Sun's Altitude by a Quadrant or Staff, and note it down: and likewise the Degrees cut by the Index at the Eye-end, and that is the Sun's Magnetical Azimuth at that time.

The Amplitude Compass. If you unscrew the Perpendicular from the Sight, then you have the Compass ready to take an Amplitude at the Sun's Rising or Setting: but more of that in the following Treatise, when we shall touch upon *Astronomy*.

When you make use of the Compass for Surveying of Land, you have a Brass Socket screwed fast to the bottom of the inward Box that holds the Chart: In that Socket you put the head of your three-leg'd *Surveying-Staff*, with a small screw on the side to fasten it to the head, that it may not stir when the Compass is set North and South, as before directed; then you may turn the Index and Sights to what object you please, and be sure of your Angle from the Meridian, if your Chart be good, and the Needle well touched and placed. *How the Needles of the Compass must be set.* Those that make them should have a special care of that; and that the Points of the Needle be fastned and cemented together, so that they do not stir, as I have seen in many Charts carelesly made. I would advise all ingenious Mariners to make a constant practice of taking observation of the Sun's Azimuth; and steer a Course, and make allowance accordingly, by a Meridian Compass, as hath been shewed elsewhere; and then this Instrument will come to the Truth, as well as a Needle of greater charge, or the *Plain Table*, or the *Theodolite*, *Circumferenter*, or *Peracter*. And yet I cannot but highly commend these Instruments as very useful. *Of the Devices of Instruments.* Neither dare I reject as useless, either the *Topographical Instrument* and *Cross-Staff* of Mr. *Diggs*, the *Familiar Staff* of Mr. *John Blagrave*, the *Geodetical Staff*, and *Topographical Glass* of Mr. *Arthur Hopton*, the *Sector Cross-Staff*, and the *Panderon* of Mr. *George Atwel*, or any other witty Invention which hath been devised for the exact Plotting, and speedy Mensuration of all manner of Superficies, as Land, and the like. But in regard the Authors have in their own Works, to their exceeding Commendation, described the Making and Use of the said Instruments; I shall say no more.

And for the Mariner's Compass in a manner to do the same things for the Surveying of Land, I hope will be well taken and accepted of all ingenious Mariners, for whose sake I take this pains.

Let the Glass over the Chart be as clear as possibly you can get it.

The Staff. The Figure of the Staff is plain, it needs no further description: it is to be had at any Instrument-Makers.

Of

Of Chains there are several sorts, as namely, Foot-Chains, each Link containing a Foot or 12 Inches; so the whole Pole or Perch will contain 16 ½ Links or Feet according to the Statute Pole.

The Chains now used, and in most esteem among Surveyors are three: as, First, *Rathborn's*, which had every Perch divided into 100 Links: and that of *Gunter's*, which hath 4 Perches or Poles divided into 100 Links: So that each Link of *Gunter's* Chain is as long as four of *Rathborn's*. And *Wing* hath described a Chain of 20 Links in a Perch, for the more ready use in his Art of Surveying. Therefore when we have taken the Angles, and plotted a piece of ground, we will shew how to know the contents thereof in Acres, Roods, and Perches, by the two last Chains.

SECT. I. *Gunter's* Chain.

GUnter's Chain, is a Chain most used amongst the Surveyors of this Age, and is always made to contain 4 Poles, and each Pole 25 Links, and each Link 7 Inches $\frac{92}{100}$ of an Inch. In measuring with this Chain, you are to take notice of only Chains and Links; saying, such a Line measured by the Chain contains 64 Chains 45 Links, or thus distinguished 64. 45.

Now for the ready counting of the Links; at every Perch let there be two Curtain-Rings fastned, and one Ring at every five Links: so you may readily count the Rings at either end. If the Ingenious Mariner wants a Chain, he may mark a six Thread-line, as before directed, with Red Cloth and White for distinction, or bits of Leather, as we mark our *Dipsey Line*; and be sure to stretch him well first; or if you can, let it be a Top-gallant Brace half worn; then measure it exactly, and mark him as before directed, and you may measure any piece of Land or Plantation, or any distance, as well in dry or wet Weather, as with a Chain, without sensible Errour.

SECT. II. *Cautions to be observed in the use of any* Chain.

WHen you have occasion to measure large distances, you may by chance mistake or miss a Chain or two in keeping your account, which will breed a considerable Error; and also in measuring of distances, in going along by a Hedge-side you can hardly keep your Instrument, Chain and Mark, in a right Line; and therefore the distance will be more than in reality it is. For avoiding these mistakes, you ought to provide ten small sticks, which let him that leadeth the Chain, carry in his Hand before; and at the end of every one of those Chains, stick one of these Sticks or Arrows into the Ground, which let him that followeth take up; so going on until the whole number of Sticks be spent, and then you may conclude you have measured ten Chains without further trouble: and these ten Chains, if the distance be large, you call a Change, and so you may denominate every large distance by Changes, Chains, and Links, in a piece of Paper where you keep the account.

SECT. III. *How to reduce any Number of Chains and Links into Feet and Yards.*

IN taking of Heights and Distances hereafter taught, it is necessary to give your measure in Feet and Yards, by reducing of your Chains and Links, thus:

Multiply your Numbers of Chains and Links, as one whole Number by 66, cutting off the Product the two last Figures towards the right Hand; so shall the Figures to the left Hand be Feet, and the Figures cut off shall be 100 parts of a Foot.

Let

Examples.

5 : 32	8 : 06
66	66
3192	4836
3192	4836
351, 12	531, 96

2
351[117
333

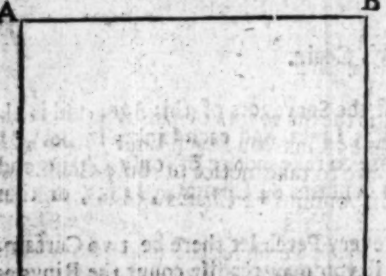
Let it be required to know how many Feet are contained in 5 Chains, 32 Links. Set down the Chains and Links with a Colon (:) thus; and these Multiplied by 66, the Sum will be 351 Feet and $\frac{12}{100}$ parts of a Foot, as thus you see it stand 351 : 12. This is the Rule by *Gunter*'s Chain.

If you divide the Feet by 3, the Quotient will be 117 Yards. Now if you have less than 10 Links, as 6, you must always remember to put 0 before the 6, and multiply the number as you see in the last Example.

SECT. IV. *How to cast up the Content of any piece of Land in Acres, Roods, and Perches, by* Gunter's *Chain.*

BY a Statute made the 33 of *Edward* the First, an Acre of Ground ought to contain 160 square Perches, and every Rood of Land 40 square Perches, and every Perch contains 16 ½ Feet; and 4 Perches or Poles, in breadth, and 40 in length makes an Acre: which multiplied together is 160, half an Acre is 80, a quarter 40 square Perches.

A B



D C

Suppose the Figure A B C D were a square piece of Ground (as the Marsh of *Bristol*), and were 15 Chain 16 Links every way: Then to find how many Acres, Roods, and Perches are in it, do thus: Square the sides, that is, Multiply one in the other, and cut off the five last Figures to the right hand, and that before is Acres: what remains, multiply by 4 (for 4 Roods makes an Acre) and cut off five Figures as before, and before the Comma is Roods; that which remains, multiply by 40 the number of Perch in a Rood, and cut off five figures to the right hand of the Product; and in like manner you have the odd Perches. This *Example* will make all clear and plain.

So you will find 15 Chains, 16 Links multiplied together, as before directed, will produce 22, 98256: the 5 last Figures cut off to the left hand, there remains before the Comma 22, which is 22 *Acres*, and the 5 Figures cut off, multiplied by 4, the Product is 393024: 5 Figures cut off on the left hand, the remainder is 3 Roods; and the 5 last *Figures* multiplied by 40, cutting off 5 *Figures*, and the rest will be 37 Perch.

	15 :	16
	15 :	16
	90	96
	151	6
	7580	
	1516	
Acres	22,	98256
		4
Roods	3,	93024
		40
Perch	37,	20960

By the Line of Numbers.

Extend the Compasses on the Line of Numbers (on the Scale of Scales) from 10 unto the side of the Square A B 15 *Ch.* 16 *Lin.* the same extent will reach from 15 *Ch.* 16 *Lin.* to 22 Acres $\frac{9}{10}$.

SECT. V. *How to measure a Long Square piece of Ground by a Chain of 20 Links to a Perch, according to* Wing.

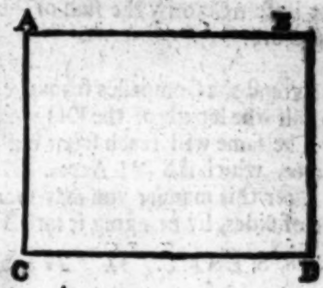
WIng in his Art of Surveying, in the 113 *Page*, hath described a Chain of 20 Links in a Perch, which is somewhat more ready, if you will reckon the Land in Perches for small parcels of Land.

Suppose a piece of Land be in length 36 Perches and 16 Links, and in the breadth 3 Perches 2 Links: By this Chain I desire to know the Contents thereof, having 20 Links in a Perch, I desire to perform the Operation in a Decimal way; count by half the number of Links, and then the Sums will stand thus; and cutting off 2 Figures, you have for the Content of the piece of Ground 114 Perches $\frac{8}{100}$ parts. But I would advise the Practitioner in greater parcels of Land, to follow *Gunter*'s Chain, Surveyors all generally making use of it: therefore, for further Use of *Wing*'s Chain, I refer you to his Book of the Art of Surveying.

368
31
368
1104
114 : 08

SECT.

SECT. VI. *To measure a long Square piece of Ground.*



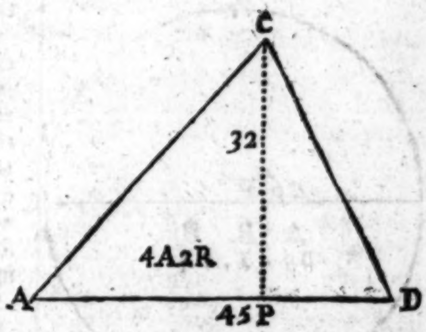
LET the piece of Ground be A BCD whose length AB is 11 Chains 25 Links, or 45 Perch, and his breadth AC 8 Chains, or 32 Perch. Multiply one by the other, as before in the last *Example* directed by *Gunter's* Chain; and you will find the Content of the Ground to be 9 Acres just.

By the Line of Numbers.

Extend the Compasses from the □ Center, which is at 160 Perch unto the length AB 45, and the same distance will reach from the breadth A C 32 Perch, to 9 Acres.

SECT. VII. *To measure a Triangular piece of Ground.*

SUppose the Base of a Triangular piece of Ground A D, whose measure is 11 Chains 25 Links, or 45 Perch, and the perpendicular C P 32 Perch, or 8 Chains; Take the half thereof, and multiply the Base by ½ the Perpendicular, it will produce the Content of the Triangle to be 4 Acres, 2 Roods.

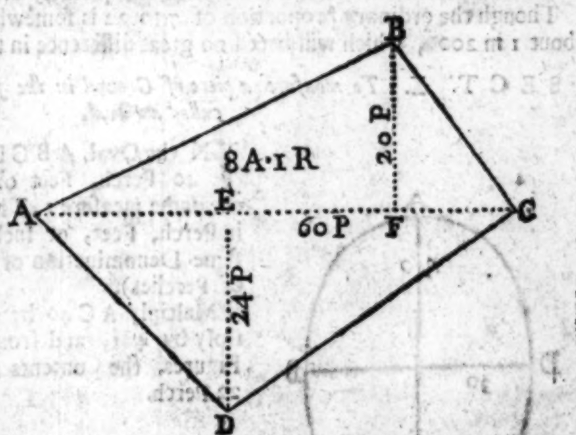


By the Line of Numbers.

Extend the Compasses from the △ Center, which is at 320 — unto the Base A D—45, the same extent will reach from the Perpendicular C P 32 unto the quantity of Acres, which is 4 Acres ½ as before.

SECT. VIII. *To measure a piece of Ground of four unequal sides, called a Trapezia.*

LEt the Ground given be A B C D; after you have taken the Angles with your Compass, and noted them down in a piece of Paper or Field-Book, (as shall be shewn in the following Discourse) you must Protract or lay down the Figure as I do this, by a Scale of equal parts of 10, 15, 20, 23, or 30 parts in an Inch; (I have laid down all that follow by 20 parts or Perch in an Inch) then draw the Diagonal Line A C, and with your Compasses take the distance A C, and apply it to your Scale of 20 Perch to an Inch; and you will find it 60 Perch, or 15 Chain; and then if you let fall the perpendiculars B F and D E, and measure them in the like manner, you will find by your Scale BF 20 Perch, or 5 Chain, and D E 24 Perch, or 6 Chain.



In respect the Base is common to both the Triangles: You may therefore add the two perpendiculars together, 20 and 24, the Sum will be 44, the half thereof is 22 Perch. This Number being multiplied by the length of the common Base AC,

60 Perch, giveth 1320 Perch, that divided by 160, gives the Contents of the Trapezia or piece of Ground to be 8 Acres, 1 Rood. You might have multiplied half the Base AC 30 by the ſum of the two perpendiculars 44, and it gives you the ſame as before.

By the Line of Numbers.

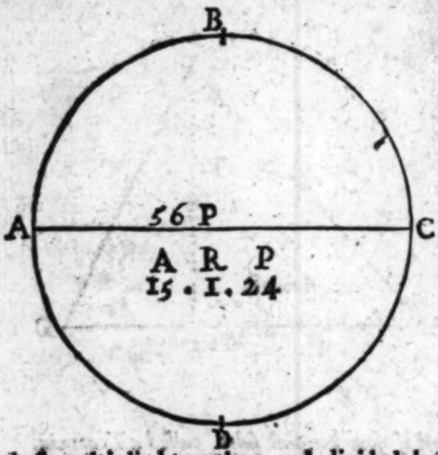
Extend the Compaſſes from the △ Center at 320 to half the length of the Diagonal AC 30

The ſame will reach from the Sum of the perpendiculars 44, to the quantity of Acres, which is 8 $\frac{35}{100}$ Acres.

After this manner you may meaſure a piece of Ground of 5, 6, 7, 8, or any number of Sides, by bringing it into Triangles and Trapezias, as ſhall be ſhewn hereafter.

SECT. IX. *To meaſure a piece of Ground in the form of a Circle.*

MUltiply the Diameter into it ſelf, and multiply that Product by 11, and divide by 14, the Quotient is the Area of the Circle. *Example.* In this Circle ABCD let the Diameter thereof be 56 Perches, Feet, or Inches, which multiplied in it ſelf giveth 3136. This Number multiplied by 11, gives 34496, which being divided by 14, the Quotient will be 2464, that is the Area of the Circle.



How many Poles, Feet, or ſquare-Inches, are in any Circle whatſoever, you may know alſo by this Rule; Firſt, if you know the Diameter, and would find the Circumference, ſay as 7 to 22, ſo the Diameter 56 to the Circumference 176; or if you know the Circumference, and would find the Diameter, ſay, as 22 to 7, ſo is the Circumference 176, to the Diameter 56.

The Diameter and Circumference being thus known; the Rule to find the Content is this.

The Diameter being 56 Perch, and the Circumference 176, the half of each of theſe multiplied together, and divided by 160, will give the Content, *viz.* Acres 15, Roods 1, Perch 24.

By the Line of Numbers.

Extend the Compaſſes from O Center at 203 $\frac{7}{10}$, unto the Diameter AC 56, the ſame diſtance will reach again from 56 to the quantity of Acres 15 $\frac{4}{10}$.

Though the ordinary proportion of 7 to 22 is ſomewhat too much; yet it is but about 1 in 2000, which will breed no great difference in theſe Queſtions.

SECT. X. *To meaſure a piece of Ground in the form of an Ellipſis, commonly called an Oval.*

IN the Oval ABCD, let the length be given 40 Perch, Feet or Inches; and DB 30 of the ſame meaſure: Then to find the Quantity in Perch, Feet, or Inches; (if you work by the ſame Denomination of Feet and Inches, as I do of Perches).

Multiply AC 40 by DC 30, the Product multiply by 491, and from that Product cut off 5 Figures, the Contents will be 5 Acres, 3 Roods, 22 Perch.

By the Line of Numbers.

Extend the Compaſſes from the o Center in the Line at 203 $\frac{7}{10}$ to the length of the Oval AC 40, the ſame diſtance will reach from the breadth DB 30 unto the Contents in Acres, 5 Acres $\frac{7}{10}$ *fere.*

SECT.

SECT. XI. *To measure a piece of Ground lying in form of a Sector of a Circle.*

Let the Sector be ABC, whose sides is AB, or AC 48 Perch, and the Arch thereof BC 30 Perch: Then to find the Contents in Acres, multiply AB 48 by BC 30, the Product divide by 320, the Quotient is 4 Acres, and 160 remains, which divided by 2 the Quotient is 80 Perch; so the Contents of this piece of Ground is 4 Acres, 2 Rood.

By the Line of Numbers.

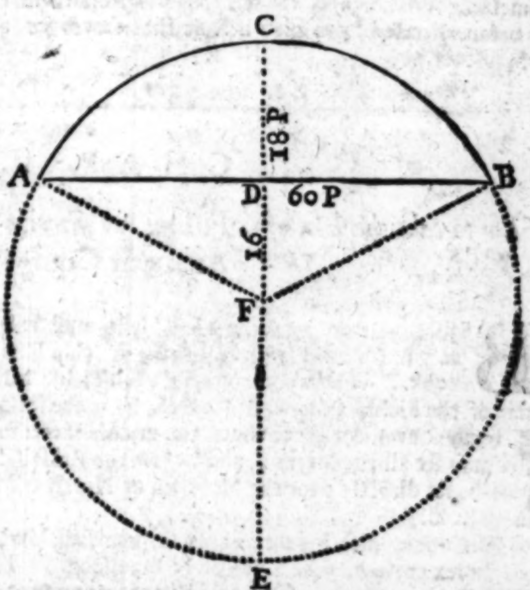
Extend the Compasses from the △ Center at 320 unto the side, (or Semidiameter) AB or AC 48, the same distance will reach from BC 30, to the quantity of Acres 4 and $\frac{5}{10}$.

SECT. XII. *To measure a piece of Ground being the Segment of a Circle.*

Let the Segment be represented by ABC, in which AB is 60 Perch, and DC 18 Perch. First, find the Diameter of the Circle, thus, As DC 18, is to the half of AB (that is AD) 30: So is AD 30 to DE 50; add DC 18, the Sum is 68 the Diameter CE.

Then find the Area of the Circle ACBE by *Sect. 9.* which will be 3633 Perch.

Then find the length of the Arch ACB in Degrees and Minutes, thus, As FB 34, to AD 30: So is the Radius, to the Sine of 61 Degrees 55 Minutes, which doubled is 123 deg. 50 min. or 123 deg. $\frac{5}{6}$.



Then find the Area of the Sector AFBC thus: As 360 deg. to 123 deg. $\frac{5}{6}$, so is 3633 the Area of the Circle, to 1249 Perch the Area of the Sector.

Then find the Content of the Triangle AFB by *Sect. 7.* which is 480 Perch.

Then substract the Area of the Triangle 480, from the Area of the Sector 1249 the Remainder 769 Perch is the Content of the Segment ACB; which reduced to Acres makes 4 Acres, 3 Rood, 9 Perch.

Note, If it be required to find the Content of the Segment AEB, which is bigger than a Semicircle, you must add the Area of the Triangle AFB to the Area of the Sector AEBF, and the Sum is the Content of the Segment.

SECT. XIII. *A piece of Ground being measured by the Statute-Perch of 16 $\frac{1}{2}$ Foot, To know how many Acres it is, it being measured by a Perch of 21 Foot, which is the Irish Perch.*

Example. A Piece of Ground being found 9 Acres by the Statute-Perch of 16 $\frac{1}{2}$ Foot; and you would know how many it is by the Irish Perch of 21 Foot.

By the Line of Numbers.

Extend the Compasses from the Irish Perch of 21 Foot to the English Statute-Perch of

of 16 ½ Foot, the same distance will reach from 9 Acres turned twice over unto 5 $\frac{6}{11}$ Acres, *fere*: Or in the Scale of Reduction extend the Compasses from 16 ½ Foot to 21, the same distance will reach from 9 to 5 $\frac{6}{11}$ in the Line of Numbers. And so of any other measure. Now by reducing the 9 Acres into Perches, it makes 1440 Perch; and because the greater measure is to be reduced into the lesser, Multiply the given Quantity 1440 by 121 the Square of 11, it produces 174240, (which 11 was found thus, 16 ½ being a Fraction, and reduced into halves makes 33, divided by 3 is 11: So the Irish-Perch 21 Foot in halves is 42, divided by 3 is 14, those two Numbers squared, *viz*. the square of 11 is 121, the square of 14 is 196): the Product 174240, divide by 196 the square of 14, and the Quotient is 888 $\frac{192}{196}$ Perch, reduced into Acres, is 5 Acres, 2 Roods, 8 Perch $\frac{192}{196}$, that is almost 9 Perch, according to the Irish Measure.

Suppose you had been to reduce Irish-Measure into Statute-measure, then multiply 1440 by 196, and the Product would have been 282240: that divided by 121, the Quotient had been 2332 ½ Perches, which make Acres 14, Rood 2, Perch 12 ½ Statute-measure.

By the Line of Numbers.

Extend the Compasses in the Scale of Reduction from 21 Foot the Irish Perch, to the Statute Perch 16 foot ½: the same will reach from 9 Acres Irish in the Line of Numbers, to 14 Acres ½ Statute-measure.

Or if you extend the Compasses from 21 in the Line of Numbers to 16 and ½; that extent turned twice over from 9, will fall upon 14 and ½ Acres, and a little more.

So that if you remember in all sorts of measure to reduce your Fractions into the same Denomination, and seek out the least proportional terms, by squaring these terms as before directed, you have a Rule that serves for all sorts of Customary measure whatsoever.

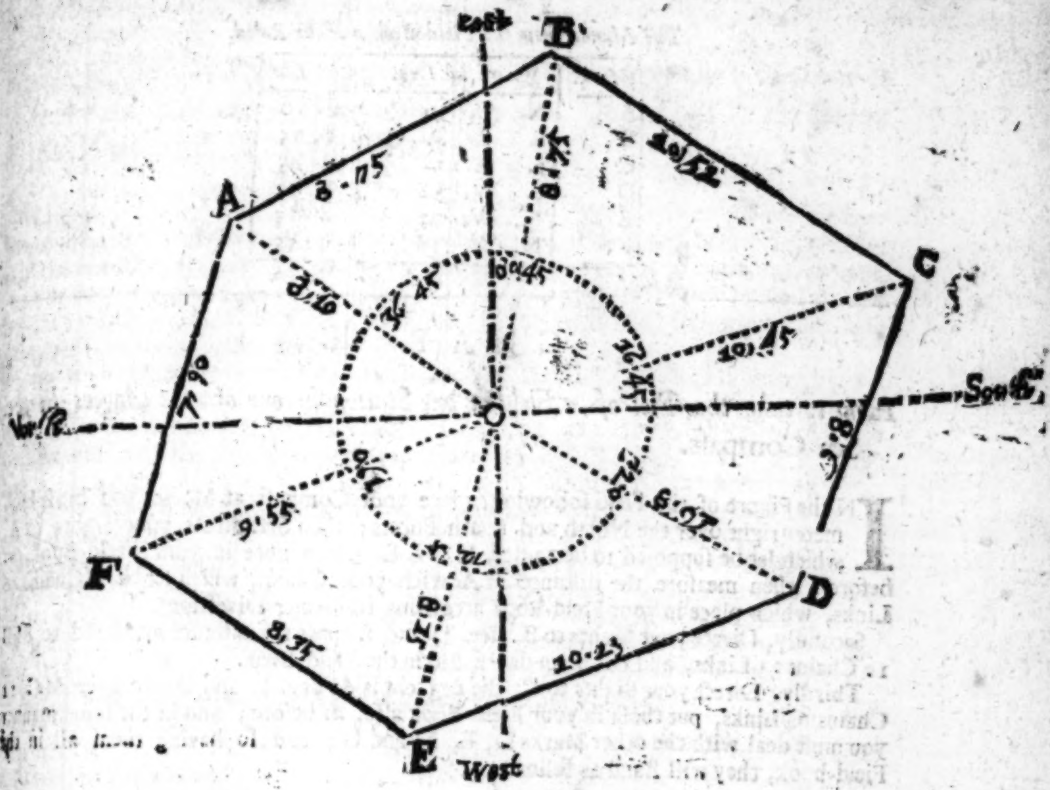
CHAP. II.

How to take the Plot of a Field at one Station in the middle thereof by the Azimuth Compass.

Before you go into the Field, you must rule a piece of Paper in 8 Columns as you see the Figure following in this Chapter, which is called a Field-Book. When you come into the Field, first place Marks at the several Angles of the Field, as at A, B, C, D, E, F, in the following Figure; then make choice of some convenient place about the middle thereof at o, to fix your Compass, that you may see all the Marks; and be sure the Brass-Diameter and Slits, before described, be set directly over the Meridian or North and South Line of the Chart, and there fixed.

This done, direct your Sights to your first Mark at A, observing what Degrees the Index cutteth, which let be N E 36 Deg. ½: This you must note down in your Field-Book in 1 2 and 3 Columns thereof, as you see in the Book it is set down; then measure the distance from o the place of the Compass to A your first Mark, which let contain 8 Chains, 10 Links, which must be placed in the 4 and 5 Columns of your Field-Book.

Then direct your Sights to B the second Mark, and note the Degrees cut by the Index, which let be South Easterly 80 Degrees ½, and the Distance 8 Chains 75 Links. You must put them down in the Field-Book, as before; First, the Letter B; Secondly, the Angle with the Meridian cut by the Index South Easterly 80 Deg. ½ in the second and third Columns, then 8 Chains 75 Links in the fourth and fifth, as you may see in the Book; then direct your Sights to C your third Mark, and note the Degrees cut by the Index, which let be S E 16 Deg. ½, and the distance o C 10 Chains 45 Links, put the same down in the Field-Book likewise, as before directed; then direct your Sights to D, and note the Degrees cut by the Index, which let be S W 32 deg. the distance o D, 8 Chains 53 Links, note it down in the



the Book, as before. Then direct your Sights to E, the Index cutting 72 deg. $\frac{1}{4}$ North Westerly ; and the distance O E 8 Chains 15 Links : They must be noted in the Book as the rest are. Lastly, direct your Sights to F your last Mark, the Edge of the Index cutting in the upper Brass Circle N. W. 18 deg. the distance O F 9 Chains 55 Links ; then will the Observations stand in the Field-Book, as in the following Table or Figure.

Then by a Line of Chords, or by the Protractor you may presently protract the exact Figure of the Field upon Paper thus ; By a Line of Chords ; take 60 deg. and draw a Circle. Secondly, draw the Meridian Line of North and South, and the Line of East and West. Thirdly, in your first Observation the deg. cut by the Index was 36 deg. $\frac{1}{2}$ N. E. Therefore take 36 deg. $\frac{1}{2}$ off the Line of Chords ; and lay from the Meridian Line to the East. Fourthly, the distance O A was found 8 Chains 10 Links ; take with your Compass off any Scale of equal parts, 8 and $\frac{1}{10}$ (that stands for 8 Chains 10 Links) lay this distance from O to A, and draw the prick'd Line O A.

Then secondly, take out of the Line of Chords the second Angle S. E. 80 deg. $\frac{1}{2}$, and lay from the South towards the East on the obscure Arch, and through it draw the Line O B ; then take off the same Scale of equal parts 8 Chains 75 Links, that is, 8 $\frac{75}{100}$, and lay it from O to B, in a prick'd Line, and draw the black Line A B, which measure with your Compasses, and apply it to the Scale of equal parts as before, and you will find the side A B 8 Chains 75 Links. The like do by all the other Angles and Distances in the same manner as you have been shewed in the two first Angles. The Figure makes it so plain, it needs no further Precept ; and you may put down the Numbers on the side.

Now by the Protractor described in the Second Book.

You may lay the Diameter-Edg thereof on the North and South Line, and through the Center put a Pin on the Center of the Plot at O, and note the deg. and distances in the Field-Book, as before : the first was North Easterly 36 deg. $\frac{1}{2}$, put the Edge of the Index to 36 deg. $\frac{1}{2}$ in the Arch of the Protractor ; and by the Edge account in the Scale thereof 8 Chains 10 Links ; and by the side thereof draw the Line A O, pricked as before ; and so do by the rest of the Angles and Sides in like manner, and you may presently draw a Plot of Ground which you have measured. The Observations marked in the Field-Book stand as in the following Table.

Turn the Protractor after you have laid down all the Angles in the N. E. and S. E. Quarters, and lay the *Center-Pin* of the Protractor on the Point O, as before ; and the Diameter of the Meridian Line

The Manner how the Field-Book must be Ruled.

Mark.	*Quar.*	*Deg.*	*Ch*	*Lin*
A	N. E.	36 $\frac{3}{4}$	08	10
B	S. E.	80 $\frac{3}{4}$	8	75
C	S. E.	16 $\frac{3}{4}$	10	45
D	S. W.	32	8	53
E	N. W.	72 $\frac{3}{4}$	8	15
F	N. W.	18	9	55

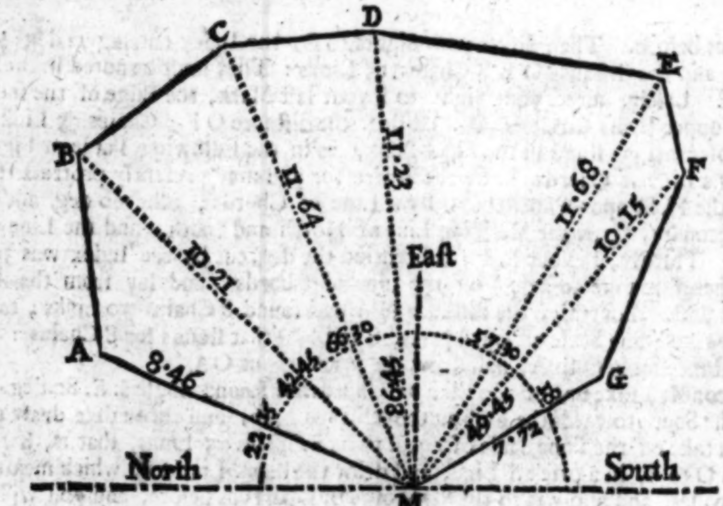
CHAP. III.

How to take the Plot of a Field at one Station in one of the Angles by the Sea-Compass.

IN the Figure of the Field following, place your Compass at M, set you brass Diameter right over the North and South Points; then first direct your Sights to A, which let be supposed to be 22 deg. $\frac{1}{4}$. N. E. which note in your Field-Book, as before; then measure the distance M A with your Chain, which let be 8 Chains 46 Links, which place in your Field-Book according to former Directions.

Secondly, Direct your Sights to B, deg. $\frac{3}{4}$, and suppose the distance measured to M B 10 Chains 21 Links, and put them down also in the Field-Book.

Thirdly, Direct your Sights to C, the deg. cut is 66 deg. $\frac{1}{2}$, and the distance M C 11 Chains 64 Links, put these in your Field-Book also, as before; and in the same manner you must deal with the other Marks D, E, F, and G; and so having them all in the Field-book, they will stand as followeth:



The Figure of the Field-Book.

M		Deg. M.	C.	L.	North.	South.	East.	West.
A	N E	22 $\frac{1}{4}$	8	46				
B	N E	42 $\frac{3}{4}$	10	21				
C	N E	66 $\frac{1}{2}$	11	64				
D	N E	86 $\frac{1}{4}$	11	23				
E	S E	57 $\frac{1}{2}$	11	68				
F	S E	49 $\frac{1}{4}$	10	15				
G	S E	18	7	72				

CHAP. IV.

How to measure any Piece of Ground, be it never so Irregular: And how to reduce the Sides unto Triangles or Trapezias, and to cast up the Content thereof in Acres, Roods and Perches.

SUppose you were to measure a Piece of Ground, Wood, or Marsh, or any place whatsoever, by your Compass, and Line marked as the 4 Pole-Chain before described in the first Chapter; and if you cannot see all the Angles, by reason of the bigness thereof, then you may measure round about by the sides thereof, as in this Figure following, and the Observations made in the Field are set down in the Field-Book following, which is so plain that it need no further precept.

Suppose you made your first Observation at A in the Field in the following Figure, (the Compass being rectified as before directed) you direct your Sights along the Hedge to the Mark in the corner at B, and the Index cuts 54 deg. from the Southwestwards, and the distance is 5 Chains 12 Links, which set down in your Field-Book thus: A B, S W, 54 deg. 5 Chains 12 Links; Then make your second Station at B and direct your Sights to C, the Index cuts N W 45 deg. 2 Chains 89 Links, which note down in your Field-Book as you did before in the second place; and so do by all the rest. From C to D, N W 76 deg. 3 Chains 35 Links, from D to E, N E 31 deg. 4 Chains 55 Links, from E to F, N E 56 deg. 2 Chains 87 Links, from F to G, N E 21 deg. 2 Chains 30 Links, from G to H, S E 51 deg. 2 Chains 95 Links, from H to K, S E 34 deg. 3 Chains 25 Links, from K to A, S W 4 deg. 2 Chains 95 Links; Thus all the Observation being plainly set down in the Feild-Book; you may proceed to protracting your places of Observation and Marks in the Field, and your degrees and length of Lines as they are placed in your Field-Book, we proceed to examine the truth of the Survey thus.

First, As the Radius or Sine of 90 deg. is to the length of the side of the Field in Chains and Links, or Perches and 100 parts; so is the Sine of the degrees cut by the Index to the length of the parallel of East and West in Chains and Links, or Perches and 100 parts.

Therefore on your Scale extend the Compasses from the Sine of 90 to the length of the side of the Field in the Line of Numbers, the same distance will reach from the degrees cut by the Index to the length in the Parallel of East or West.

Secondly, As the Radius or Sine of 90 degrees to the length of the side of the Field in Chains and Links, or Perches and 100 parts, so is the Sine Complement of the degrees cut by the Index to the length of the Meridian either North or South in Chains and Links, or Perches and 100 parts.

Wherefore extend the Compasses from the Sine of 90 degrees to the length of the side of the Field in the Line of Numbers; the same distance will reach from the Sine Complement of the degrees cut by the Index to the length North or South in the Meridian.

Now to know by the Chains and Links. The first Observation from A to B, is S W 54 deg. and the distance A B is 5 Chains 12 Links; therefore by the last Rule extend the Compasses from 90 deg. to 5 Chains 12 Links, in the Line of Numbers, that distance will reach from 54 deg. cut by the Index to 4 Chains 14 Links in the Line of Numbers, which is the distance in the Parallel of West, and also the same extent will reach from the Complement of 54 deg. wich is 36 deg. to 2 Chains 97 Links in the Line of Numbers, which is the distance in the Meridian South and put it in the South Column of your Field-Book as you did 4 Chains 14 Links in the Column of West; and so you may do with the rest of the Observations.

Or you may convert your Chain and Links into Perches and 100 parts of a Perch, and then you may Protract in Perches and 100 parts; as I have done in the Example following.

Thus if you multiply the number of Chains found in the side by 4, (by reason 4 Perches are in a Chain) and if there be above 25 Links in the Place of Links, divide by 25, and the Quotient will shew the odd Perch to be added; and what remains multiply by 4 likewise, the Product will be 100 parts of a Perch.

As for Example.

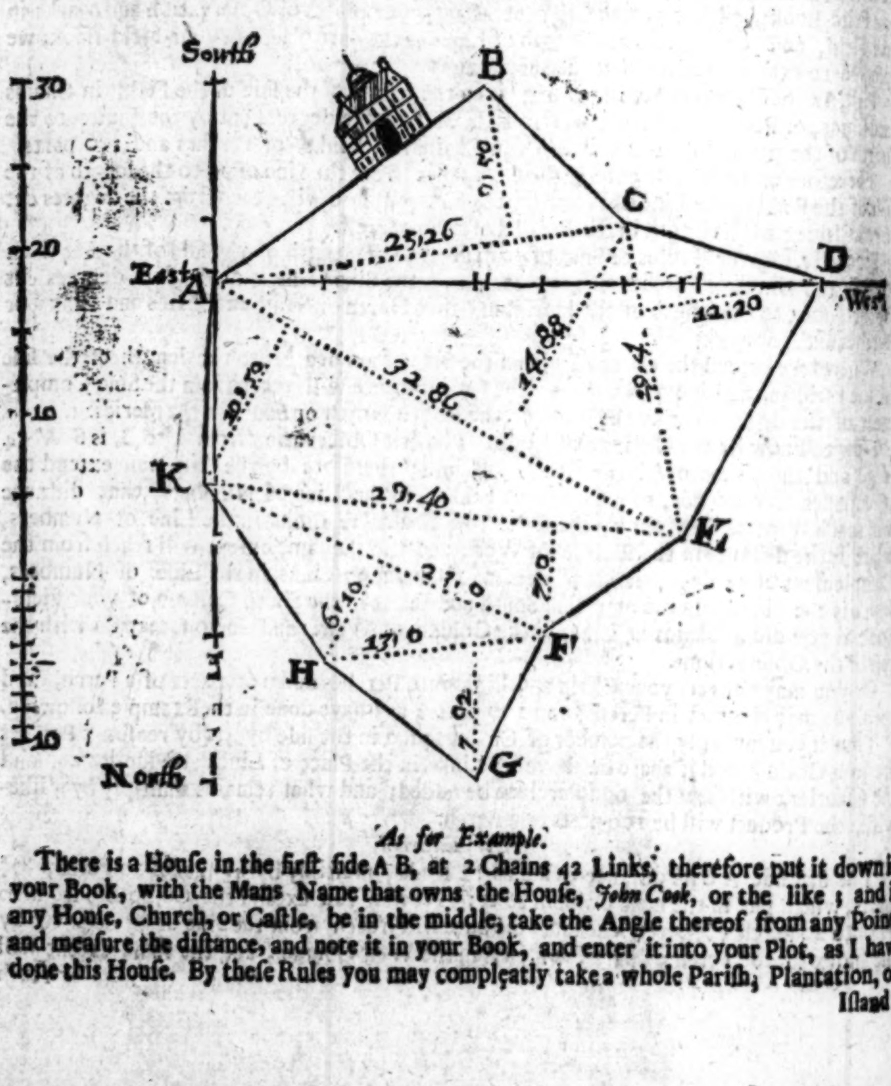
The first side A B its distance 5 Chains 12 Links, multiply by 4, makes 20 Perch, $\frac{48}{100}$ parts, which put in the next Column to it: Now if you extend the Compasses from 90 deg. to 20 Perch $\frac{48}{100}$ parts, the same distance will reach from the Sine of 45 deg. cut by the Index to 16 Perch 57 parts, which is in the West Column, and the same extent will reach

reach from the Complement of 54 deg. which is 36 deg. to 12 Perch, 4 parts, which I put in the South Column: and by the same Rule I work in like manner in the rest of the Observations. The second side B C is 2 Chains 89 Links, reduced as before, makes 11 Perch $\frac{56}{100}$ parts; and so working with them as before directed, you shall have all your Numbers as in this Figure of the Field-Book.

When you have in this manner compleated all the Numbers of the four last Columns, add them up severally; and if you find the Sum of the N. Column to agree with the S. Column, and that of the East to agree with the West, you may conclude the Observations are truly made; if not, there is an Error.

Houses Names.	Sides.	Ang. with Merid.	Ch. Li.	Pol. pts.	North.	South.	East.	West.
John Cook	A B	S W : 54 Deg.	5 12	20 48		12 4		16 57
2.42.	B C	N W : 45	2 89	11 56	8 18			8 18
	C D	N W : 76	3 35	13 40	3 23			13 02
	D E	N E : 31	4 55	18 20	15 60		9 37	
	E F	N E : 56	2 87	11 48	6 42		9 51	
	F G	N E : 21	2 30	9 20	8 59		3 29	
	G H	S E : 51	2 95	11 80		7 43	9 17	
	H K	S E : 34	3 25	13 00		10 78	7 26	
	K A	S W : 4	2 95	11 80		11 77		83
				The Sums	42 02	42 02	38 60	38 60

If there be any Houses by the Hedge side, make a mark in your Field-Book in that Angle, how many Chains or Perch from the place you observe, and so insert it in your Plot.



As for Example.

There is a House in the first side A B, at 2 Chains 42 Links, therefore put it down in your Book, with the Mans Name that owns the House, *John Cook*, or the like; and if any House, Church, or Castle, be in the middle, take the Angle thereof from any Point, and measure the distance, and note it in your Book, and enter it into your Plot, as I have done this House. By these Rules you may compleatly take a whole Parish, Plantation, or Island:

Iland: Now if you draw a Plot by the Protractor described in the Book of Instruments, you must rule your Paper or Parchment with an obscure Meridian-Line, and Parallel Lines about 1 Inch and $\frac{1}{2}$ asunder; and putting the Center-Pin upon any Point, turn the side of the Protractor Parallel to the Meridian, and look in the Field-Book for the Angle, and put the Edge of the Index to the degrees, and count the Perches on the Index, there make a Mark with your Pin for the second place, and draw a Line from that place by the Edge of the Ruler for the side of the Hedge or Field.

As for Example.

Suppose you were to draw the side A B in the Plot with your Protractor, lay the Diameter-Edge of your Protractor to the Meridian Line; then in the opposite Degree and Quarter which in this Example is N E: I put the Foot of the Index to 54 Degrees, and from the Center, the Edge points S W 54 deg. then number the Chains, and Links, or 20 Perches 48 Parts, and from that Number to the Center draw a Line by the Edge thereof, and you have the side A B; by this Rule you may gain all the rest.

Now we shall proceed to find the just Quantity or Content of this Piece of Ground.

WE have shewed in the fore-going Chapter, how to measure the Geometrical Square, the Parallelogram, the Triangle, Trapezium, the Circle, and the like. Now we will shew you how to cast up the Content of any Field whatsoever. Suppose the fore-going Figure A B C D E F G H K being drawn or protracted by a Scale of 10 Perches in an Inch, and the Content thereof is required. Now because it is an irregular Plot, neither in the form of a Square, Parallelogram, Trapezium, nor Triangle; therefore I reduce the main Body of the Field into the Trapezium A C E K, and the Residue of it into 5 Triangles, as A B C, C D E, E F K, F H K and F G H.

Now to know the just Quantity of Acres, Roods, and Perches the Field contains, I first measure the Trapezium A C E K, taking with my Compasses the length of the Perpendicular C O, and apply it to my Scale of 10 Perches in an Inch, and find it 14 Perches $\frac{88}{100}$ parts; and likewise the Perpendicular K P, and find it 10 Perches, 50 parts, which I add together, and they make 25 Perches, 38 Parts, which I multiply in half the Base A E 16 : 43, and the Product is 416 : 9934: Therefore if you cut off 4 Figures to the right hand, you will have the Contents of the Trapezium 416 Perches, and $\frac{99}{100}$ parts, rejecting the two last Figures.

In the like manner for the Triangle A B C, I multiply half the Perpendicular 4 : 75 by the whole Base 25 Perches 26 Parts, or the whole Perpendicular by half the Base, as before, it is all one: and the Product is the Content of the Triangle A B C 119 Perchse 98 Parts: and so likewise for the Triangle C D E, multiply half the Base 9 Perch 52 Parts, by 12 Perches 20 Parts the Perpendicular, and the Product is 116 Perches 14 Parts, the Contents of that Triangle. Likewise in the Triangle E F K, the length of the Perpendicular is 7 Perches, and the half length of the Base is 14 Perches 70 Parts, the Product is 102 Perches 90 Parts, the Content of that Triangle E F K: In the Triangle F H K the Perpendicular is 6 : 10, half the Base F K 11 : 50, the Content is 70 Perches 15 Parts: In the Triangle F G H the Perpendicular is 7 : 92, and the Base 13, the half thereof is 6 : 50; these multiplied together, the Product is 51 : 48, for the Triangle F G H.

Lastly, I add the several Sums together, and they give the Content of the whole Figure in Perches and 100 Parts.

The Area or Content of the	*Trapezium*	A C E K	416 : 99
	1 *Triangle*	A B C	119 : 98
	2 *Triangle*	C D E	116 : 14
	3 *Triangle*	E F K	102 : 90
	4 *Triangle*	F H K	70 : 15
	5 *Triangle*	F G H	51 : 48
The Area or Content of the whole Field or Wood is			877 : 64

Which if you will reduce into Acres, Roods, and Perches, you must divide 877 Perches by 160, the Quotient shews the Acres to be 5; that which remains above 40 divide by 40, and the Quotient will be Roods 1: and that which remains will be 37 Perches. So that the whole Content of the said Field is 5 Acres, 1 Rood, 37 Perches, and $\frac{64}{100}$ of a Perch.

This is the way to cast up the Content of any irregular Field, by reducing it into Trapeziums and Triangles, and adding their several Products into one Sum, which ought

heedfully to be regarded, it being one of the most material works belonging to the Practice of a Surveyor; for unless he be perfect herein, he can never perform any Work of that nature aright. I have been brief and plain in shewing the Art of Surveying by the Sea-Compass; I might have been longer, but to avoid Prolixity, I think what is writ is sufficient: If any desire a larger Discourse, he may make use of *Leybourn*, *Wing*, &c.

CHAP. V.

How to take the Height of any Island, or Mountain in the Sea by an Example made by the Author of the Height of Teneriff.

MAny Learned Men have writ of the great Height of several Hills and Islands in the World. For taking of the Height of Islands in the Sea, none have greater opportunities than Sea-men. By them may all Men be informed of the truth of such like things.

It is reported of *Aristotle*, *Mela*, *Pliny*, and *Solinus* of the incredible Height of *Athos*, a Hill in *Macedonia*, and of *Caucasus*, and of *Cassius* in *Syria*, and many other places: and among the rest one of the most miraculous things which they have observed of the Mountain *Athos*, is, that it being a Hill situated in *Macedonia*, casts a shadow into the Market-place in *Myrrhina*, a Town in the Island *Lemnos*, distant from *Athos* 86 Miles to the Eastward. But it is no marvel it casts so long a shadow, seeing by Experience of the shadow of a Man's body, we find it extraordinary long at Sun-Rising, or Sun-Setting. They report it is higher than the Region of the Air. *Julius Scaliger* writes from other Men's Relations, that the *Pico* of *Teneriff* riseth in height 15 Leagues, or 60 Miles: Most Writers agree, that it is the highest Mountain in the World, yet that this Island cannot be so high, shall appear by the following Observation.

Patricius, not content with the former Measure of sixty Miles high, reaches to seventy Miles high: Now that any Snow is generated sixty or seventy Miles above the plain Superficies of the Earth and Water, is more than ever they can perswade any Man that understands these things, seeing that the highest Vapours never arise by *Ptolomy* 41 Miles, and by *Eratosthenes*'s Measure 48 Miles above the Earth; that is there is never any Rain, Dew, Hall, Snow or Wind, but still a clear serenity: But the Snow lies upon the *Pico* of *Teneriff* all the Year, except the Months of *June* and therefore it cannot be so high

I have passed by *Teneriff* several times my self; in the Year 1652 I was there in the *Castle-Frigot* of *London*, Captain *John Wall* Commander, and Loaded our Ship at *Garrachica*, right under the *Pico*. And since bound to the *West-Indies* in the Year 1656, in the *Society* of *Topsam*, a Ship I had Command of, was so put by Westerly Winds to the Eastward, that we had sight of the *Pico* of *Teneriff*, it bore off us North; about Noon I was resolved to make Observations of the height thereof, to try Conclusions with my Quadrant of 20 Inches Semidiameter, described in Chapter 16 of the second Book, and I made these Observations following: On the fifth of May 1656, I observed, and found the Suns apparent Meridian Altitude 81 deg. 48 min. his Declination 19 deg. 8 min. the Latitude 27 deg. 20 min. the Latitude of *Pico* I found formerly to be 28 deg. 20 min. difference of Latitude 60 min. which in the following Figure I make one half of my Horizontal Base AD; then at the same time Observing the Height or Altitude of *Pico*, I found it 24 deg. 14 min. Therefore according to the Sphericity of this Terrestrial Globe, consisting of the Earth and Sea, I drew the following Figure, the Section of the Arch A E f N represents the Arch of a great Circle, being the Meridian; E B a second Observation, N the North part of the Horizon, S the South part, C the Port of *Garrachica*.

See Figure 98 in the following Schemes.

But having three days of Fair Weather, in sight of *Pico* I made a second Observation, and ran to it with my Ship untill I made an Angle with the *Pico* of 45 deg. as the Angle at B; and had the apparent Meridian Altitude of the Sun 81 deg. 29 min. the Declination 19 deg. 22 min. Latitude the Ship is in 27 deg. 53 min. difference of Latitude 27 min. being equal to the height of *Pico*.

But touching the Hypothesis, that the Earth and Sea makes a round Body, it is generally agreed upon by all the *Philosophers*, *Astronomers*, *Geographers*, and *Navigators* Ancient and Modern; and the distance of a degree 60 min. reckoned in the Heavens, by Observations of the Sun or Stars, is more than sixty English measured Miles upon the Superficies of the

the Earth and Sea, as appears by several Experiments made by able Artists; but especially by the Labour and Industry of our own Country-man Mr. *Richard Norwood*, as you may see in his second Chapter of his Book, The *Sea-man's Practice*, measuring betwixt *York* and *London*. He makes it evident that 1 Degree of a great Circle on the Earth, is near 367200 Feet, which in our Statute-Poles of 16 and ½ Feet to the Pole is 22254 Poles, and about a half, and these reduced into Furlongs at 40 Poles to a Furlong, make 556 Furlongs and 14 Perches; and lastly, these reduced into English Miles of 8 Furlongs to a Mile, make 69 Miles and 4 Furlongs 14 Poles, that is, 69 and ½ Miles and 14 Poles to 1 Degree upon the Superficies of the Earth and Sea. And seeing a Degree is the 360 part of any Circle, equally divided in the Circumference: Therefore if we can find how many Feet, Perches, Furlongs, or Paces, are in a Degree of known Measure: then can we presently resolve how many are in the Circumference of any Circle so divided on the Earth and Sea; for if there is 367200 Feet in one Degree of a great Circle upon the Superficies of the Earth and Sea; it is evident, that if you multiply 367200 by 360 deg. the Product is 132192000 Feet, which reduced into Poles, is 8011636 and these reduced into Furlongs, are 200290 Furlongs, and 36 Poles: And lastly, these reduced into Miles, are 25036 English Miles and more for the Circumference of the Earth and Sea.

And now if you desire the Diameter and Semidiameter of the Earth, as it is proved by *Archimedes*, That the proportion of the Circumference of a Circle is to the Diameter thereof almost as 22 to 7; by the Rule of Proportion, multiply the Circumference of the Earth; namely, 132192000 by 7, and divide the Product 925344000 by 22, the Quotient is 42061091, which is the Diameter of the Earth in Feet: and the half thereof, namely, 21030545 is the Semidiameter of the same, or distance of the Superficies of the Earth and Sea from the Center, being 21 millions of Feet, and a little more; and these reduced into Miles, as we did the Circumference, shews the Diameter of the Earth to be 7966 Miles, and somewhat more: and the distance to the Center or Semidiameter 3983 Miles; and thus is found the Circumference, Diameter, and Semidiameter of the Earth and Sea, and also the quantity of a Degree of the same measure in English Measures of Feet, Perches, Roods, and Miles. Therefore if you do still retain a deg. in the Heavens to be 60 minutes, you may find how many Feet is in a Mile on the Earth and Water, if you divide 367200 feet by 60, the Quotient will be 6120 feet; which doubled, and divided by 33, the half-feet to a Perch, the Quotient is 370 Perches, and 30 foot remains: divide 370 by 40 Perches to a Furlong, and the Quotient is 9 Furlongs, and 10 Perches or Poles remain, divided by 8, the Furlongs in a Mile, the Quotient is 1, and 1 remains; so that a minute in the Heavens by this Experiment upon the Superficies of the Earth and Water, contains 1 Mile, 1 Furlong, 10 Perches, and 30 foot; therefore my 60 min. Difference of Latitude at my first Observation, is found by these Rules to be 69 and ½ Miles, 14 Perches, my distance upon the Arch of a great Circle from *Pico*: Therefore working by the Rules given in the 16*th* Chapter of the second Book, the true height of *Pico* will be found to be 31 $\frac{14}{100}$ Miles, and the distance from the Eye to the Top of the *Pico* will be found by the Rules in the 16*th* Chapter 76 $\frac{15}{100}$ Miles.

And working the second Observation by the same Rules, your difference of Latitude 27 Minutes BD will be found to be 31 Miles, 2 Furlongs, 14 Perches, 19 Foot, which is 31 $\frac{29}{100}$ Miles; which is almost the same Height found by the first Observation: and the distance from the Eye to the top of the *Pico* is 44 $\frac{25}{100}$ Miles.

By comparing two Observations made by Mr. *Harry*, an ingenious Navigator, in two several Voyages, the height of the *Pico* in *Teneriff* is 2100 Geometrical Paces, that is, two Miles (of 1000 Paces) and $\frac{1}{10}$, and this, to all knowing Men, will appear to be nearer the truth, than this Observation of the Authors. *This was inserted by* John Colson, *Teacher of the Mathematicks in* London.

CHAP. VI.

How to find the distance of a Fort, or Walls of a City, or Castle, that you dare not approach for fear of Gun-shot: Or the breadth of a River or Water, that you cannot pass, or measure over it; made by two Stations.

Suppose from some private place, as at A, you espy a Castle, Fort, Tree, or any place whatsoever, that you cannot approach for Gun-shot, Marsh-grounds, or a River betwixt you, or some other Impediment, that you cannot make your second Station *See Figure 90 in the following Sheets.*

tion in any open place, but are forced to make it in some other secure Place at B; therefore plant your Instrument or Compass at A, and direct the Sights to C and B, take the Quantity of the Angle C A B 46 deg. and go to B, and take the Quantity of the Angle A B C 79 deg. then measure the distance of the two Stations A and B 350 fathoms: And because the Sum of the Angles C A B and A B C is 125, therefore the Angle at C must be 55, the Complement to 180.

Then by a Plain Scale, or by the Line of Sines on the Scale or Scales, you may presently resolve the distance, as I do by the Tables,

As the Sine of 55 deg.	A C B	991336
to 350 Fathoms,	A B	254406
So is the Sine of 79 deg.	A B C	999194
to the distance		1253600
A C 419 : $\frac{1}{10}$		262264

As the Sine of 55 deg.	A C B	991336
is to A B 350 Fathoms		254406
So is the Sine of 46 deg.	C A B	985693
to B C 307 $\frac{1}{10}$ Fathoms, the		1240099
distance required.		248763

SECT. I. *How to take the Breadth of a River.*

SUppose you were to take the breadth of a River, as I did at *Crocken-Pill*, which runs betwixt *Gloucester-shire*, and *Somerset-shire*, and found the breadth of the Water upon a Spring-Tide 40 Perches or a Furlong; you must do it thus: being on the River-side, as in the former Figure at E, there set your Compass, and observe some Mark on the other side of the Water, as at D; then set a Mark at E, and go square-wise, either to the right-hand, or to the left from these two marks, so far, until you spie the mark D on the other side the Water, doth justly make an Angle of 45 deg. with the mark E, as here at f; then measure carefully f E, the distance of the two Stations, and that shall be equal to the breadth of the River: so that if f E be 10 : 20 : 30 : 40 : 50 : or 100 Poles, or Yards, or Feet, the breadth is the same. Or if you go to G, and make an Angle of 26 deg. 30 min. in D; then is the distance G E twice the breadth; but if you can, get an Angle of 45 deg. for that is the best and readiest to measure the breadth.

SECT. II. *Being upon the Top of a Hill, Tower, or Steeple, to find the true distance of any Object therefrom.*

TAke the Angle from the Top of the Tower to the Object with your Quadrant.

Example.

Let the height of the Tower, or Hill be 40 Yards, and let the Angle taken with your Quadrant be 80 degrees, (being 10 degrees under the Line of Level;) then say:

As the Tangent Compl. 80 deg. (which is 10 *d.*)	924631
is to the height 40 Yards.	160206
So is the Radius	100000
to the distance from the foot of the Tower 226 $\frac{8}{10}$	235575 *Yards.*

SECT. III. *By the way of your Ship, and any two Angles of Position, to find the distance of any Island, Cape, or Head-Land from you.*

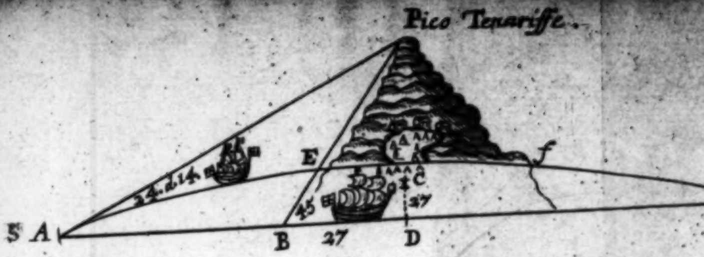
YOu have been shewed how to do it with an Angle of 45 deg. already; but with a little more trouble, you may do it by any two Angles whatsoever.

As for Example.

See Figure 100 in the following Sheets.

Suppose you are sailing full South from A towards B, and from A should espy Land at C, bearing two Points from you to the Westward, as S S W, or S W 22 deg. 30 min. and sailing still upon your Course untill you come to B, you observe the Place bears from you just four Points, or S W 45 degrees, which is the double of the Angle observed at A. If in this manner you double any Angle; that is, let your first Angle be what it will, you must

98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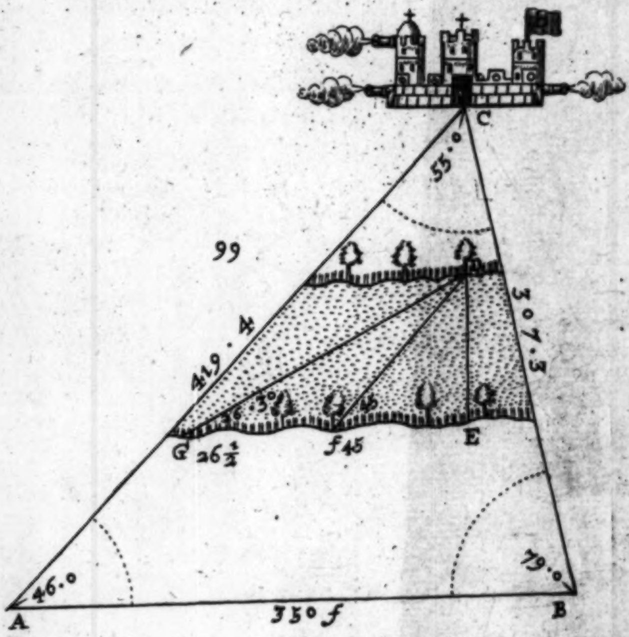
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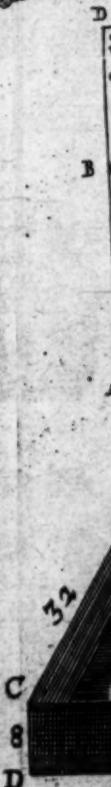
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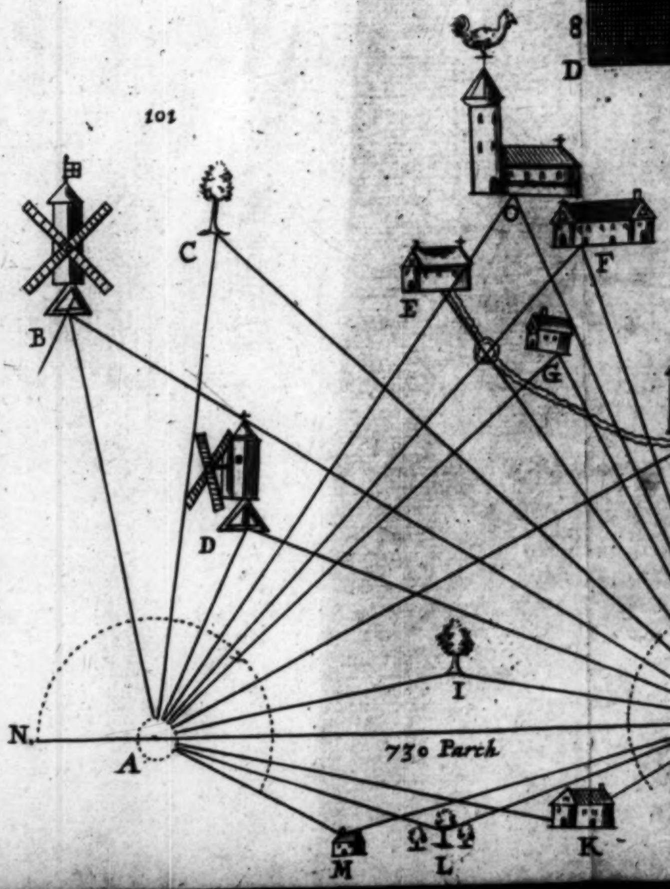
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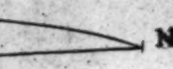

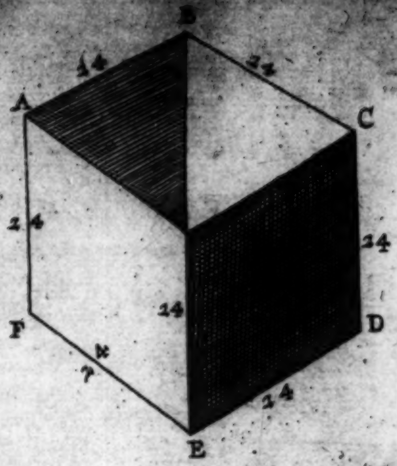

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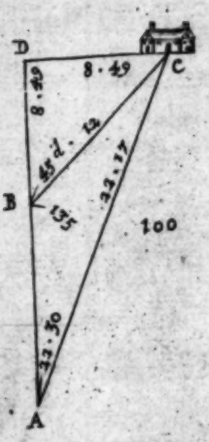

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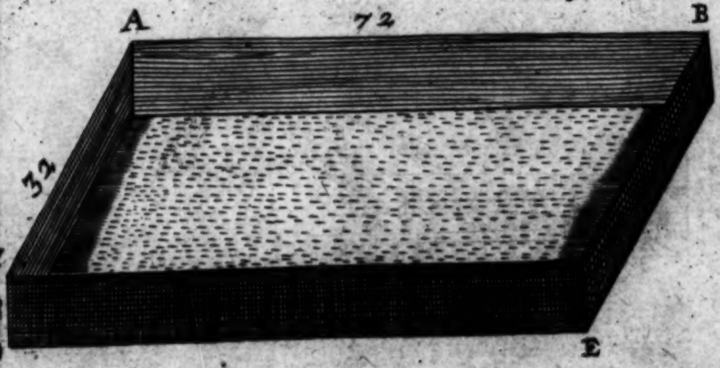

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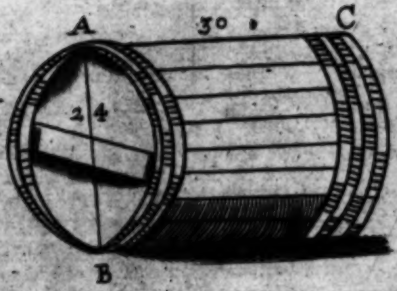


105

Sail until you have doubled that Number ; then you may assure your self that the ance you have sailed between A and B, is equal to the distance between B and C. So if A B be 12 miles, B C is likewise 12 miles ; and this you may do without further uble or Calculation.

all such Questions remember that the Angles at the second place of Observation be either just the double, if you go nearer to the Place, or else just the half if you go ther off than the Angle at the first place. Therefore the first Angle you may take at dom, no matter what it is, so you be careful to observe when you be just upon the dou-, or the half.

That this is so, is plain from 32. 1. of *Euclid.* which is, that the outward Angle of any iangle is equal to the two inward opposite Angles ; *viz.* the outward Angle D B C is al to the two inward opposite Angles B A C and A C B : And therefore if the outward gle D B C be the double of the inward Angle B A C, then it follows that the two in- rd Angles are equal to each other, and that their opposite sides A B and B C are equal ach other ; by the 6. 1. of *Euclid.*

CHAP. VII.

to take the Distance of divers places one from the other, remote from you, according to their true Situation in Plano, and to make a Map there- of by the Compass and Plain-Scale.

THis Problem serveth chiefly to describe upon Paper or Parchment all the most E- minent and Remarkable Places in a Country, Town or City, whereby a Map thereof may be exactly made by help of a Table of Observations following, as with a lit- Practice you may soon perceive.

Upon some high Piece of Ground make choice of two Stations as A and P, from whence may plainly discern all the principal Places which you intend to describe in your ; then at A fix your Compass, and turn the Index about to P ; and suppose A and one off the other North and South as you see marked with the Letters N and S, and direct your Sights to the several Marks from A to B, C, D, E, O, F, G, H, I, L, and M, observing what degree the Index cutteth. As suppose your Instrument at A, and the Sights directed to B, the Index cutteth in E 83 deg. 50 min. and wise the Index directed to C cuts S E 82 deg. 5 min. and so in like manner take the of the Angles, as you see them in the Table following, which must be noted down ou in a Paper-Book as they are taken. *See Figure 101.*

	Places	*Angles*	*deg.*		*min.*
The Stationary Distances 730 Perches, or 2 miles 90 Perches.	AB	NE	83	:	50
	AC	SE	82	:	05
	AD	SE	64	:	50
	AE	SE	56	:	20
	AF	SE	45	:	26
	AG	SE	41	:	30
	AH	SE	24	:	40
	AI	SE	09	:	00
	AK	SW	11	:	00
	AL	SW	16	:	00
	AM	SW	23	:	00

The Stationary distance A P, which was found 730 Perches, you must note down like- wise in your Book ; then set your Compass and fix it at P, that the Chard may stand North and South on the Stationary-Line P A, then turn the Index to the Mark K, the Index N W 24 degrees ; Likewise turn the sights to L, and mark the Inclination to the Meridian, and put it down N W 17 deg. and so do by all the rest of the former Marks Points ; and note them down as you see in this Table P K, P L, P M, P I, P D, P B, C, P E, PG, PO, P F, P H, then protract these Observations, and where the Lines drawn from A and P Intersect each other, there must you describe the several Places, to which you made Observation, where you may write the Names of the Places.

Places	*Angles*	*Deg.*	*Min.*
P K	N W	24 :	00
P L	N W	17 :	00
P M	N W	12 :	00
P I	N E	9 :	00
P D	N E	21 :	00
P B	N E	33 :	50
P C	N E	43 :	40
P E	N E	54 :	10
P G	N E	64 :	00
P O	N E	68 :	50
P F	N E	73 :	20
P H	N E	87 :	15

See Figure 101.

Lastly, If you would know the Distance of any of the Places thus described, one from another, you have no more to do, but open your Compasses to the two Places on the Paper; and then apply it to the same Scale, by which you laid down the Stationary Distance A P, (which in this Figure was laid down by a Scale of 20 Perches to an Inch), and so applied, it will give the distance sought.

You must remember always in taking of Inaccessible Heights and Distances, that you take the two stationary distances as far asunder as may be. And if at any time you require the Altitude of a Church, Castle, or Tree, standing upon a Hill, you must perform it at two Operations; first by taking the Altitude of the Church, Castle, Tree, and Hill together as one Altitude; and secondly, by taking the Altitude of the Hill alone; then by subtracting the height of the Hill from the whole height, the remainder shall be the height of the Castle, or the like.

And here Note also, That in the taking of all manner of Altitudes, whether accessible or inaccessible, you must always add the height of your Instrument from the Ground to the height found, the total is the true height. And thus much briefly touching this Matter.

The ART of Gaging of Vessels.

CHAP. VIII.

The Use of the Line of Numbers, the Lines on the Gaging-Rod or Staff, and the Rules in Arithmetick in Gaging of all sorts of Vessels, (viz.) *to Gage a Cubical, and a Cylindrical Vessel; also, Barrels, Pipes, or Hogsheads; to measure a Vessel part out, to measure a Brewer's-Tun, or a Mash-Fat, to measure a Conical Vessel, to measure a Rising or Convex Crown; and also a Convex or Falling Crown in a Brewer's Copper; also a Brewer's Oval Tun.*

PROB. I. *How to find the Gage-Point of a Wine or Ale Gallon.*

THE Gage-Point is the Diameter of a Circle whose superficial Content is equal to the solid Content of the Wine or Ale Gallons; so the solid Content of a Wine Gallon, according to *Winchester* measure, being 231 Cube-Inches: If you conceive a Circle to contain so many Inches, you shall find the Diameter thereof to be 17 : 15 by this Rule. As 1 to 1.2732, so is 231 to 294.1092; whose square root 17 : 15 *fere* is the Gage-point for a Wine Gallon. Thus likewise you may discover the Gage-Point for an Ale-Gallon containing 282 Cubique Inches; for as 1 is to 1.2732, so is 282 to 359.0424, whose square-root is 18 : 95 *fere*, the Gage-Point for Ale-measure.

Note, you must be very careful in your Dimensions of all sorts of Vessels, *viz.* their length, breadth, and depth, as also the Diameters of the Head and Bong; for all small Errors in them will increase very much in the Content.

The

The Description of the Gaging-Rod, or Staff.

A very useful Gaging-Rod may be thus made, in length 48 Inches, upon one Square there is two Lines, a Line of Numbers and a Line of 48 Inches, every Inch divided into ten parts for the ready measuring of any Vessel's length, breadth, or depth.

But for the measuring of Great Vessels, there is two Rods divided into Inches and ten parts, made to slide by each other.

On the second side is two Lines, the first for the Head, and the second for the Bong, which added together and multiplied by the length, will give the Content; As by the Example in the sixth Problem.

On the third side is two Diagonal Lines, the one for the Gage of Wine; and the other for Ale; which shews the Contents to the $\frac{1}{10}$ part of a Gallon. The Use is shewn in Prob. 6.

On the fourth side is a Line of Segments, or 63 Gallons divided in 1000 parts, as you may see in the Use by the following Table in Prob. 7.

The Description of Symbols used for Brevity-sake.

$+$ *Plus* or *Addition*, which is to say add.	*C* *Cube* the *Number*.
$-$ *Minus* or *Subtraction*, then you must subtract.	Z *Sum*; and Z*q* *Square* of the *Sum*.
$\times$ *In* or *Multiplication*, now you are to multiply.	$\surd q$ To *Extract* the *Square Root*.
$\frac{\ }{2}$ To *divide* by 2, or any *Number* under the *Line*.	X Difference.
$=$ *Equal* to.	X*q* *Square* of the *difference*.
q *Square* the *Number* given.	

PROB. II. *How to measure a Cubical Vessel.*

Suppose we have a Cubical Vessel to measure, whose sides let be A B C D E F, which let be every way 24 Inches, and I desire to know how many Gallons of Wine or Ale the same will hold. *See Figure 102 in the following Schemes.*

For Beer or Ale by the Line of Numbers.

Extend the Compasses always from the Gage-Point (which for Ale is 16 $\frac{8}{10}$) unto the side of the Cube 24 Inches, the same extent will reach from the same 24, turning twice over unto 49 Gallons, and better.

For Wine. Extend the Compasses always from the Gage-Point, which for Wine is 15 $\frac{2}{10}$ unto the side of the Cube 24 Inches: the same extent will reach from the same 24, turning twice over unto 59 $\frac{8}{10}$ Gallons, which is almost 60 Gallons of Wine.

The Arithmetical way

$\frac{AB,c}{282}$ = Gallons of Ale 49. $\frac{AB,c}{231}$ = Gallons of Wine 59 $\frac{8}{10}$.

PROB. III. *How to measure a Vessel in the form of a Parallelipipedon.*

Suppose we have a Vessel to measure, whose side A B let be 72 Inches, and breadth AC 32, and the depth CD 8 Inches.

By the Line of Numbers for Ale.

You must first find a mean proportion between the length A B 72, and the breadth A C 32, by multiplying it together, and taking the Square Root thereof, or taking the middle point between 72, and 32 on the Line of Numbers, and you will find 48 for the mean. *See Figure 103.*

Now Extending the Compasses from the Gage-point 16 $\frac{8}{10}$ to the mean Number 48 Inches, the same extent will reach from the depth CD 8 Inches, turning twice over unto 65 $\frac{3}{10}$ *Gallons.*

For Wine. To find how many Wine-Gallons it is, work by the Gage-point 15 $\frac{2}{10}$ as you did in the last Rule, and you will find near 79 $\frac{8}{10}$ Gallons; or you may find a mean proportion between the breadth A C 32, and the depth CD 8: which will be 16 Inches, and so work according to the former Rule.

How to work the same without the Gage-Point.

Example for Ale. Extend the Compasses from the Ale-Gallon 282 unto the length AB 72; the same distance will reach from the breadth A C 32 unto 8 $\frac{17}{100}$ Gallons, for an Inch depth, so for 8 Inches you may presently find it to be 65 $\frac{36}{100}$ Gallons.

For Wine Gallons. Take 231 for the first Number, and by the former work you shall find 9 $\frac{97}{100}$ Gallons for 1 Inch depth.

The

The Arithmetical way. $\dfrac{AB \times AC \times CD}{282}$ = *Ale-Gallons* 65 $\frac{14}{100}$.

$\dfrac{AB \times AC \times CD}{231}$ = *Wine-Gallons* 76 $\frac{8}{10}$.

PROB. IV. *How to measure a Cylindrical Vessel.*

See Figure 104. SUppose the Diameter of the Head A B be 24 Inches, and the length thereof A C be 30 Inches, To find the Contents in Ale-Gallons. Extend the Compasses always from the Gage-point, which for Ale is 18 $\frac{95}{100}$ Inches unto the Diameter 24 Inches; the same distance will reach from the length 30 Inches turned twice over unto 48 $\frac{13}{100}$ Gallons.

For Wine. Extend the Compasses from the Gage-point 17 $\frac{15}{100}$ unto the Diameter 24; the same distance will reach from 30 turned twice over to 58 $\frac{77}{100}$ Gallons.

The Arithmetical way. For Ale. $\dfrac{ABq \times AC}{359}$ = *Ale-Gallons (viz.)* 48 $\frac{13}{100}$.

For Wine. $\dfrac{ABq \times AC}{294}$ = *Wine-Gallons, (viz.)* 58 $\frac{77}{100}$.

PROB. V. *How to measure a Globical Vessel.*

See Figure 105. SUppose the Diameter of the Globe be A B 24 Inches: Then to know the Contents in Ale or Wine, it is thus.

For Ale. Extend the Compasses from the Gage-point, which is 23 $\frac{2}{10}$ unto the Diameter A B 24 Inches; the same distance will reach from the same 24 turned twice over unto 25 $\frac{2}{3}$ Gallons of Ale.

For Wine. Extend the Compasses from the Gage-point 21 unto the Diameter 24 turned twice over, as before, you shall have 31 $\frac{1}{3}$ Gallons.

The Arithmetical way. For Ale. $\dfrac{AB,c}{538}$ = *Gallons, (viz.)* 25 $\frac{69}{100}$.

For Wine. $\dfrac{AB,c}{441}$ = *Gallons, (viz.)* 31 $\frac{35}{100}$.

PROB. VI. *How to measure a Barrel, Pipe, Butt, Puncheon, Hogshead, or small Cask.*

See Figure 106. SUppose you have a Cask to measure, whose length is A B 27 Inches, and depth at the Bong C D 23 Inches, and breadth at the Head E F 20 Inches.

You are to find a mean-Diameter between the Head and the Bong by this Rule. Take the difference between 23 and 20, which is 3; which being multiplied by 7, the Product is 21, and divided by 10 the Quotient will be 2 $\frac{1}{10}$ which added to the lesser Diameter 20, you have 22 $\frac{1}{10}$ for the mean-Diameter.

Then for Ale. Extend the Compasses from the Gage-point 18 $\frac{95}{100}$ unto the Mean-diameter 22 $\frac{1}{10}$, the same will reach from the length 27 Inches turned twice over, to 36 $\frac{7}{10}$ Gallons.

For Wine. Extend the Compasses from the Gage-point 15 $\frac{15}{100}$ unto 22 $\frac{1}{10}$, the same will reach from 27 to 44 $\frac{6}{10}$ Gallons.

The Arithmetical way. For Ale. $\dfrac{2\,CDq \times EFq : \times AB}{1077}$ = *Gallons, (viz.)* 36 $\frac{55}{100}$.

For Wine. $\dfrac{2\,CDq \times EFq : \times AB}{882}$ = *Gallons, (viz.)* 44 $\frac{63}{100}$.

See Figure 106. There is another way to work this Vessel Arithmetically by the Mean-diameter which was before found to be 22 $\frac{1}{10}$ Inches.

Thus

Thus. *For Ale.* $\frac{MDq \times AB}{359}$ = *Gallons, (viz.)* $36\frac{71}{100}$.

For Wine. $\frac{MDq \times AB}{294}$ = *Gallons, (viz.)* $44\frac{81}{100}$.

By the Diagonal Line on the Rod and Staff.

Take the meaſure with your Rod from the Bong-hole at C to the lower part of the Head at F, as the Line F C, which in this Example ſis near $25\frac{4}{10}$ Inches: So if you would know how much Ale the Cask will hold, you ſhall find the Bong hole to cut in the Diagonal Line $36\frac{7}{10}$ Gallons. And for Wine it will cut $44\frac{1}{4}$ Gallons the Contents required.

The Uſe of the 2 Lines upon the Rod marked Head and Bong; and of this Table for Wine-meaſure.

A Table for the Gaging of Veſſels.

D	Head. G pts.	Bong. G pts.		Head. G pts.	Bong. G pts.
01	0.001	0.002	31	1.089	2.178
02	0.004	0.009	32	1.100	2.321
03	0.010	0.020	33	1.234	2.468
04	0.018	0.036	34	1.310	2.620
05	0.028	0.056	35	1.388	2.776
06	0.041	0.081	36	1.469	2.938
07	0.056	0.111	37	1.551	3.102
08	0.072	0.145	38	1.636	3.272
09	0.092	0.184	39	1.724	3.448
10	0.113	0.226	40	1.813	3.626
11	0.137	0.274	41	1.904	3.809
12	0.163	0.326	42	2.000	4.000
13	0.192	0.383	43	2.096	4.192
14	0.222	0.444	44	2.194	4.388
15	0.255	0.510	45	2.295	4.591
16	0.290	0.580	46	2.398	4.796
17	0.328	0.517	47	2,503	5.007
18	0.367	0.734	48	2,611	5.222
19	0.409	0.818	49	2.721	5.442
20	0.453	0.906	50	2.833	5.666
21	0.500	1.000	51	2.948	5.896
22	0.548	1.097	52	3.064	6.129
23	0.599	1,199	53	3.183	6.367
24	0.653	1.306	54	3.305	6.610
25	0.708	1.416	55	3.428	6.856
26	0.766	1.532	56	3.554	7.108
27	0.826	1.652	57	3.682	7.364
28	0.888	1.777	58	3.812	7.625
29	0.953	1.906	59	3.945	7.890
30	1.020	2.040	60	4.080	8.160

The Diameter in Inches.

Extend the Compaſſes from 231 to 282, the ſame extent will reach from the Content in Wine-Gallons $44\frac{8}{10}$ to $36\frac{7}{10}$ the Contents in Ale-Gallons.

The Uſe of this Table is the ſame with the Rod, only in the Table you have the perfect Number, but upon the Staff, for 10 account 100, for every ſmall Diviſion is 10; and you muſt eſtimate the parts of theſe ſmall Diviſions, and then is the Work all one as with this Table, *(viz).*

You muſt meaſure the Diameter firſt at the Head, and find the Number in the Table, or Rod belonging to it; then meaſure the Diameter at the Bong, and likewiſe in the Table or on the Rod, find the Number belonging to that; then add thoſe two together, and multiply the Sum thereof by the Inches of the Veſſels length, from Head to Head on the inſide.

And as 231 to 282, ſo are the Ale-Gallons to the Wine-Gallons.

The Table and Staff ſhews for 20 Inches at the Head —— 0,453
For 23 Inches at the Bong —— 1,199
Theſe two added together, make —— 1,652
27
Which being multplied by 27, the length —— 11564
—— 3304
Makes —— 44604

According to this Operation, it ſhould be 44 Gallons $\frac{604}{1000}$ parts, which difference is of no Moment in theſe Concluſions.

PROB. VII. *By the Line of Segments on the Rod or Staff, to find the Quantity of Liquor in a Cask that is part full.*

See Figure 107. SUppose you would know the Quantity of Liquor in a Cask whose depth at the Bong is 23 Inches, and let the Liquor be in height 16 Inches, and the whole Cask to hold 44 $\frac{85}{100}$ Gallons.

By the Line of Numbers on the Staff, the Proportion will be, as the whole depth 23 Inches is to the depth in Liquor 16 Inches, so is a 1000 to 695 parts.

Which being sought for in the Segment-line on the Staff, you shall have in the Line by it 741.

Now if you extend the Compasses from 1000 to 741, the same distance will reach from 44 $\frac{85}{100}$, the Content of the whole Cask to 33 $\frac{6}{10}$, that is, 33 $\frac{6}{10}$ Gallons of Wine in the Cask.

PROB. VIII. *How to measure a Brewers Tun, or a Mash-Fat.*

See Figure 108. LEt the Tun be A C D E, whose Diameter in the bottom let be E D 98 Inches, and the Diameter at the top A C let be 90 Inches, add both the Diameters together, you have 188 Inches; then take the half thereof, and it is 94 Inches, this is the Mean Diameter F G; then get the height of the Tun, which let be A B 40 Inches. Now to know how many Barrels of Beer it will hold according to 36 Gallons to the Barrel, work thus.

By the Line of Numbers. Extend the Compasses always from 113 $\frac{7}{10}$; (which is the Gage-point for a Barrel) unto the Mean-diameter 94, the same distance will reach from the height 40 Inches turned twice over unto 27 $\frac{1}{3}$ of a Barrel.

The Arithmetical way by the Mean-Diameter.

$$\frac{FGq \times AB}{359} = \text{Gallons } 984\tfrac{5}{10}.$$

Which being divided by 36, you have 27 Barrels 12 $\frac{1}{2}$ Gallons.

Or thus for Barrels.

$$\frac{FGq \times AB}{12924} = \text{Barrels } 27\tfrac{35}{100}.$$

This Arithmetical way by the Mean-diameter is not absolutely true, yet near enough for Brewers Tuns, by reason the difference of Diameters between the bottom and the top, is seldom above 7 or 8 Inches: but to do it exactly, take this way of working this Tun.

The Arithmetical way.

$$\frac{EDq + ACq; + ED \times AC, \times AB}{1077} = 985 \text{ Gallons } \tfrac{4}{10}.$$

Divide 985 $\frac{4}{10}$ Gallons by 36, and the Quotient is 27 Barrels, and 13 Gallons: So the Tun will hold 27 Barrels 13 Gallons $\frac{4}{10}$.

Or thus for Barrels.

$$\frac{EDq + ACq, + ED \times AC, \times AB}{38772} = 27 \text{ Barrels } \tfrac{37}{100}.$$

PROB. IX. *To measure a Conical Vessel, having the Height and the Diameter at the Base.*

See Figure 109. SUppose the Diameter at the Base AB be 98 Inches, and the height DC 490 Inches.

Then by the Line of Numbers for Barrels of Ale or Beer.

Extend the Compasses from the Gage-point 169 $\frac{2}{10}$ unto the Diameter A B 98, the same will reach from the height of the Cone DC 490, turned twice over unto 121 $\frac{4}{10}$ Barrels *fere*.

This is the Proportion to work for great Cones to have it in Barrels, but small Cones have it in Gallons.

Work thus. Extend the Compasses from the Gage-point 32 $\frac{8}{10}$ unto the Diameter of the Base 98, the same will reach from the height of the Cone 490, twice turned unto 4369 $\frac{4}{10}$ Gallons.

Arithmetically. For Gallons.

$$\frac{ABq \times DC}{1077} = 4369\tfrac{4}{10} \text{ Gallons}.$$

Which being divided by 36, you have 121 Barrels 13 Gallons.

Or

Or thus for Barrels. $\frac{AB q, \times DC}{38772} = 121\frac{37}{100}$ *Barrels.*

The Brewer's Tun before measured may be measured after this manner following.

To find the height of the greater Cone, say, as the difference of the Diameters 8 Inches is to the height of the Tun 40 Inches: So is the Diameter of the bottom A B 98 Inches to the greater height D C 490 Inches, from whence substract 40, there remains the height of the lesser Cone G C 450 Inches.

Now working as before for the Content of each Cone.

The greater Cone will be found to be —— 4369 *Gallons* —— 5 *Parts*

And the lesser Cone to contain —— —— 3384 *Gallons* —— 4 *Parts.*

Which substracted from the greater Cone, there remains 985 *Gallons* $\frac{1}{10}$ *Parts,* which is 27 *Barrels* 13 *Gallons* $\frac{1}{10}$.

PROB. X. *How to measure a Segment of a Globe or Sphere, which serves for the rising, or falling Crown in a Brewers Copper.*

ADmit you have the Diameter of the Crown A B 80 Inches, and the height thereof C D 6 Inches.

$$\frac{AB q + 1\frac{1}{3} CD q \times CD}{718} = 53\frac{8}{10} \text{ Gallons.}$$

PROB. XI. *How to reduce Ale Gallons into Wine Gallons.*

Example. THere is a Vessel that holds 60 Gallons of Ale; the Question is how many Gallons of Wine it will hold.

The Proportion. As 231 is to 282 : so 60 Ale to / Or as 77 is to 94 : so is 60 Ale to } $73\frac{19}{77}$ Wine Gallons.

The Reason is this, 231 Ale-Gallons is 282 Wine-Gallons, or 77 Ale-Gallons is 94 Wine-Gallons.

Extend the Compasses from the Wine-Gallon 231 to the Ale-Gallon 282, the same distance will reach from 60 to $73\frac{2}{10}$ Gallons.

PROB. XII. *How to measure a Brewers Oval Tun, whose Bases are Ellipses of different Magnitudes, having their Axes parallel to each other.*

SUppose the extreme Diameters at the bottom to be A B 120 inches, and E F 90 inches, and those at the top to be C D 112 inches, and G H 84 inches, and the depth of the Tun C b 40 inches; to find the Content in Gallons.

The Rule. $\frac{AB + \frac{1}{2}CD : \times EF + : CD + \frac{1}{2}AB : \times GH \times Cb}{1077} = 1124.9$ *Gallons.*

That is, to the greater Diameter at the bottom add half the greater Diameter at the top, and multiply that Sum by the lesser Diameter at the bottom, reserving the Product; then to the greater Diameter at the top add half the greater Diameter at the bottom, and multiply the Sum by the lesser Diameter at the top, and reserve the Product, add these two Products together, and multiply that Sum by the depth, and divide by 1077; the Quotient is the Content in Gallons; which will be found to be 1124.9 Gallons.

CHAP. IX.

Wherein is shewed both Arithmetically and Instrumentally how to measure all kind of plain Superficies, as of Walls, Timber-work, Roofs of Houses, Tyling, Board, Glass, Wainscot, Pavement, and the like; as also Timber and Stone.

PROB. I. FOrasmuch as it is very requisite for a compleat Artist to know how to measure all manner of Surfaces, as of Walls, Timber-work, Tyling, and such like; the following Example gives you the way of doing it.

Note

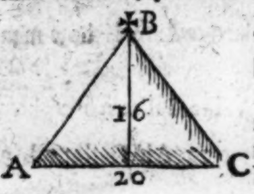
Note this, that Walls are measured by the Rod of 16 $\frac{1}{2}$ Feet, Wainscot by the Yard, and Board and Glass by the Foot. Therefore measuring any of these things, consideration must be had to the just Form and Figure thereof: Then by the following Rules you may have the Content thereof.

As for Example. Suppose there be a Wall in the form of this Figure being an oblong, and it is required to know how many Perches, or Rods are contained therein.

The Arithmetical way for Perch. $\frac{AB \times AD,}{272\frac{1}{4}}$ ——— 4 *Rod* $\frac{1}{2}$ *29 feet.*

Extend the Compasses always from 272 $\frac{1}{4}$ to the length 66, the same extent will reach from the height 19 foot unto the true Contents of the Wall 4 Rod $\frac{1}{2}$, and 29 feet.

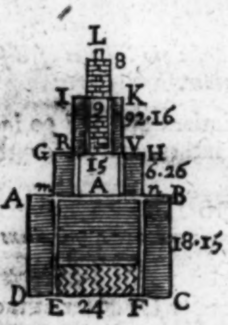
Note, that in measuring Brick-work, if the Wall be 1 Brick $\frac{1}{2}$ thick, then the Content before found is the measure of that Wall, but if the thickness be more or less, there must be an allowance made accordingly; that is, for every $\frac{1}{2}$ Brick above 1 Brick $\frac{1}{2}$ you must add $\frac{1}{3}$ of the former measure to the Content before found; for every $\frac{1}{2}$ Brick less than 1 Brick $\frac{1}{2}$ you must subtract $\frac{1}{3}$ from that measure.



But suppose A B C be a Gable end, which is in the form of a Triangle, therefore multiply 16 the Perpendicular by half the base A C 10, the Product is 160, the Content in Feet.

But in measuring of Chimneys, which require more Workmanship than other ordinary Walls, they are usually accounted as double measure, that is, first measure them as single measure, and the double of that measure produceth the Content.

Note, that if the Chimney stand by it self, the Back is to be measured with the rest of the Chimney; but the Back standing against a Wall, the Wall must not be measured with the Chimney.



Admit the Figure L I K, G H, A B, D C be a Chimney to be measured, and according to double measure, the Content is required.

1st. Measure the Brast-Wall E F, and the Jaums D E and F C, which together make 24 Feet; next take the height of the Square C B 18 : 15 Feet, which multiplied together, the Product is 435 : 60 Feet for the Content of the Figure A B D C. Then for the Square G H m n, the Brast-Wall G H, and the Jaums is 15 Feet, the height n H 6 : 26 Feet, multiplied as before, make 93 : 90 Feet, for the Content of the Square G H m n.

By the like manner of working, you will have the Contents of the Square I K R V : 92 : 16; likewise the Chimney-Shaft in compass is 9 Feet, and 8 Foot high, multiplied together as before, is 72 Feet for the Contents: Add these four Sums together, the Total is 693 : 66 Feet, doubled is 1387 Feet [illegible] Feet, the Content of the Chimney according to Customary measure.

		Feet.	Parts.
The Squares	A B D C :	435	60
	G H m n :	93	90
	I K R V :	92	16
The Shaft I L :		72	00
The Sum		693	66
doubled.		693	66
The Total Sum.		1387	32

Which reduced into Perches as before, is 5 Rod 26 Foot.

Note that Slate-work and Tyling, also Roofs of Houses, Timber-work, Partitions and Floors, are measured by the Square of 100 Foot.

PROB.

PROB. II. *How to measure Boards, Glass, Pavement, Wainscot,* &c.

IN the last Problem we have said that Boards, Glass, Pavement, and Wainscot, and the like, they are commonly accounted by the Foot or Yard; therefore to make this plain, we shall instance only upon Boards which are commonly cut out in long Squares.

How to measure them. Take the length and breadth in Inches and Parts, multiply one by the other, the Product will shew the Content in Inches; that divided by 144 (the number of Inches in one Foot) the Quotient will tell you the Number of Feet, and the remainder are Inches.

For Example. Admit I have a Board that is 7 Foot long, and 18 Inches broad; multiply 84 Inches (which is in 7 Feet) by 18 Inches, the Product is 1512; which divide by 144 the number of Inches in a Foot of Flat measure, and the Quotient shews 10 Feet, and 72 remains (which is $\frac{1}{2}$ of 144) therefore the Board contains 10 Foot $\frac{1}{2}$; but many times the Board falls out to be broader at one end than it is at the other, then add together the breadth at each end; then take the $\frac{1}{2}$ for the true breadth, and work as before.

And what have been said of Board-measure, the same is to be understood in the way of measuring not only Boards and Glass, but likewise all manner of Wainscot, Pavement, Floors, and such like; they depend upon one and the same Geometrical ground, they be reckoned by different measures, as you see by the Perch, Rod, Square, Yard, or Foot, according to the Custom of the Place, therefore it needs no further Example.

Extend the Compasses always from 12 Inches unto the breadth 18 Inches, the same extent will reach from the length 7 Foot, unto the Number of Square Foot in the Board, which is 10 $\frac{1}{2}$ Foot.

PROB. III. *Mensuration of Solids, as Timber, Stones,* &c. *and first of Squared Timber.*

WHatsoever hath length, breadth, and thickness, is called a Solid body; as Timber and Stone, and the like, which are usually measured by the Foot: and therefore you are to observe that a Foot of Timber or Stone is a Foot every way in the form of a Die.

Suppose a piece of Timber being at each end 16 Inches one way, and 25 Inches the other, and 14 Foot long, to find the Content.

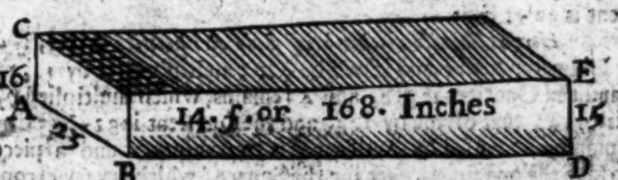
By the Line of Numbers. Take the middle between 16 and 25, which you will find to be 20, then to find the Content.

Extend the Compasses (always) from 12 Inches unto the Mean Square 20 Inches; the same will reach from the length 14 Foot turned twice over to 38 $\frac{8}{9}$ Foot of Timber.

Arithmetically thus $\dfrac{AB \times AC, \times BD}{144}$ = to the Contents in Feet 38 $\frac{128}{144}$.

Or thus, $\dfrac{AB \times AC \times BD}{1728}$ = (reduced into Inches) 38 $\frac{1536}{1728}$ Feet

Yet it is common with the Carpenters to add the breadth and thickness together, and to take the half thereof for the Mean Square, but that way is very erroneous, especially when the difference between the sides is much.



In the former Example one side is 25, the other 16, the Sum 41, the half 20 $\frac{1}{2}$ Inches; that is, half an Inch too much, for the Mean Square is but 20, so that by taking 20 $\frac{1}{2}$, it makes the piece of Timber 40 Foot $\frac{2}{9}$, when it is but 38 $\frac{8}{9}$ Feet, which is two Foot too much.

Now if a piece of Timber be tapering, the common way is to take the Square in the middle; and so to work as in the last Example, but it is erroneous.

Example. Admit a piece of Timber were 25 Inches square at one end, and 15 Inches at the other, and 14 Foot long.

This is the true way by Arithmetick.

$$\frac{ABq + DEq + Æ. \times BD}{432} = \textit{Contents } 39\tfrac{1}{10}$$

Æ is $=$ AB x DE

PROB. IV. *How to find how many Inches in length will make one Foot of Timber, in a piece that is equally squared at each end.*

SUppose you have a piece of Timber that is square 16 Inches every way, and you would know how many Inches in length will make one Foot of Timber.

By the Line of Numbers. Extend the Compasses always from 16 Inches the side of the Square to 12 Inches, the same turned twice over from 12 Inches, will reach to $6\frac{3}{4}$ Inches, the length for one Foot of Timber.

The Arithmetical way.

$$\frac{1728}{A{\cdot}C\ 16\ q} = 6\tfrac{192}{256} \text{ or } 6\tfrac{3}{4} \text{ Inches.}$$

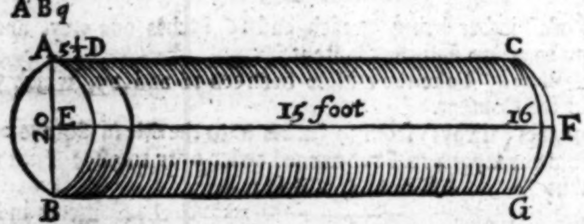
PROB. V. *How to measure round Timber.*

ADmit you were to measure a piece of round Timber, whose Diameter or thickness at either end is 20 Inches, I desire to know how many Inches in length will make one Foot of Timber.

By the Line of Numbers. Extend the Compasses from the Diameter A B 20 Inches, unto the constant Number 13, the same distance will reach from 12 turned twice over unto $5\frac{1}{2}$ Inches for 1 $\frac{1}{10}$ Foot, as A D.

The Arithmetical way.

$$\frac{2187}{A B q} = A D\ 5\tfrac{47}{100} \text{ Inches, for one Foot.}$$



Having the Diameter of a piece of Timber, as admit it to be 20 Inches, and the length suppose 15 Foot; to find the Contents in Feet.

By the Line of Numbers. Extend the Compasses always from $13\frac{5}{10}$ to the Diameter A B 20 Inches, the same distance will reach from 15 the length turned twice over unto the Contents $32\frac{7}{10}$ Feet in the piece.

The Arithmetical way. Square the Diameter A B 20, and it is 400; quadruple it by 4, and it is 1600, multiply it by the length 15, and the Product is 24000, that divide by 729 and the Content is $32\frac{7}{10}$ Feet.

Here is likewise another brief Rule Arithmetically thus,

Square the Diameter AB 20, and it will be 400; multiply that by 11, and it is 4400, divide by 14, and the Quotient is 314, and 4 remains, which multiplied by the length 15; the Product is 4714; that divide by 144, and the Quotient is $32\frac{7}{10}$.

Now the common way used by Artificers, is to measure round a piece of Timber or Tree, and to take the one fourth part for the Square, which is very erroneous and false.

For Example. The measure of the Circumference of the piece before going is $62\frac{8}{10}$ Inches, the $\frac{1}{4}$ thereof is $15\frac{7}{10}$ Inches, which they take to be the Square; which multiplied into it self, produceth $246\frac{5}{10}$ for the *Area* of the Base; which multiplied by the length 15 Foot, the Product is $3697\frac{5}{10}$ the Content in Feet and parts; that divided by 144, the Quotient is $25\frac{7}{10}$, that is differing from the Truth no less than 7 Foot, which the Buyer hath more than his due; but I conceive they agree in the Price to stand to that measure, by reason of the waste in Chips before it is brought into Squares; but the best way will be to measure the Tree right, and afterwards allow for the waste; or else in time Error will be taken for Truth, and Truth will be accounted Error, as it is by too many this day.

How

How to measure a round Piece of Tapering Timber.

Admit the Diameter of a great End of a Piece of Tapering Timber be A B 20 Inches, and the lesser End CG 16 Inches, and the length E F 15 foot. To find the Content the common way is this, add both the Diameters 20 and 16, the Sum is 36, the half is 18 for the Mean.

Then extend the Compasses always from $13\frac{5}{10}$ to the Mean-diameter 18, the same will reach from the length 15 foot turned twice over unto $26\frac{5}{10}$ foot.

The true way by Arithmetick. $\dfrac{AB\,q + CG\,q + AB \times CG : \times EF}{550}$ = *Content in Feet,* $26\frac{6}{10}$.

P R O B. VI. *How to measure a Pyramidal piece of Timber.*

Admit you have a piece of Timber to measure, whose thickness at the Base is 25 Inches A B, and breadth A C 16 Inches: And the length of the piece D E 15 Foot.

By the Line of Numbers. First, by the Line of Numbers find a Mean-proportional between 25 and 16 by dividing it into two parts, and the middle will fall upon 20 Inches, the Mean-proportional required.

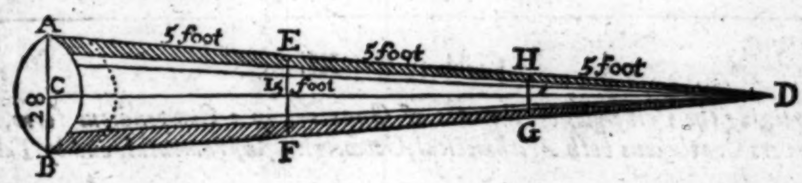
Then extend the Compasses always from $20\frac{8}{10}$ unto the Mean-proportional 20 Inches, the same distance will reach from the length 15 foot turned twice over unto $13\frac{8}{10}$ foot of Timber.

The Arithmetical way. $\dfrac{AB \times AC \times DE.}{432}$ = 13 foot $\frac{88}{100}$ parts of Timber in the piece.

Or $\dfrac{AB \times AC \times \frac{1}{3} DE}{144}$ = 13 foot $\frac{88}{100}$ parts, that is 13 foot and above three quarters.

P R O B. VII. *How to measure a Conical piece of Timber.*

Admit you had a Cone Piece of Timber, whose Base or Diameter at the End A B 28 inches, and the length thereof C D 15 foot, it is required to know how many foot of Timber is in the piece.



Extend the Compasses always from $23\frac{4}{10}$ unto the Diameter A B 28, the same distance will reach from the length 15 foot turned twice over unto $21\frac{4}{10}$.

The Arithmetical way. $\dfrac{AB\,q \times CD}{550}$ = $21\frac{35}{100}$ foot of Timber in the Cone Piece.

CHAP. X.

For the Burthen of a Ship, or her Tunnage, take these Rules following.

Suppose you were to find the Burthen of a Ship that the length of her Keel is 45 foot, the breadth of the Beam, 17 foot, the depth of her Hould 9 foot, always to find the Tunnage.

Mul-

Multiply the breadth by the length, and the Product multiply by the depth in Hould, and divide by 100, and the Quotient will shew you the Tunnage to be in this Example $68\frac{85}{100}$ Tun.

Or extend the Compasses always from 100 to 17 the breadth, the same extent will reach from 45 the length, to $7\frac{65}{100}$.

Then extend the Compasses from 1 unto $7\frac{65}{100}$, and the same distance will reach from the depth in Hould 9 foot to the Tunnage $68\frac{8}{10}$ Tun of King's Tunnage.

But for Merchants Ships, who give no allowance for Ordnance, Masts, Sails, Cables and Anchors, which is all a Burthen, and no Tunnage.

You must work thus for the Tunnage.

$$\frac{45 \times 17 \times 9}{95} = 72\frac{457}{1000} \text{ Tun Burden.}$$

Or, extend from 95 always to the length of the Keel 45, the same will reach from the breadth 17 of the Beam to a fourth Number, (as to $8\frac{05}{100}$) then extend from 1 to $8\frac{05}{100}$ the same distance will reach from the depth in Hould 9 foot to the Burden $72\frac{4}{10}$ Tun.

Having the Proportion of any one Ship in Burden, with the length of her Keel, to build another of any Burden according to that proportion.

Admit I have a Ship of 80 Tun, the length of her Keel is 46 foot. Now I am to build a Ship, whose Keel must be 65 foot of the same Mould; I desire to know how many Tun she must be.

Extend the Compasses from 46 foot unto 65 foot, the same extent will reach from the Burden 80 Tun, being turned 3 times over unto $225\frac{7}{10}$ Tuns.

Note that C signifies the Cube of the Number preceding.

The Arithmetical way. $$\frac{80 \times 65\,C}{46\,C} = 225\frac{7}{10} \text{ Tuns.}$$

Admit you had a Ship of 226 Tuns, and the length of her Keel is 65 foot; Now I would build a Ship of twice the Burden, that is 452 Tuns; Now I would desire to know the length of her Keel.

Extend the Compasses from 226 unto 452, the $\frac{1}{3}$ of that distance will reach from the length of her Keel 65 foot unto the length of the greater Ships Keel $81\frac{8}{10}$ foot *fere*.

Note, √c signifies the Cube Root of the quantity following it.

The Arithmetical way. $$\sqrt{c}:\ \frac{65.c. \times 452.}{226} = 81\frac{8}{10} \text{ foot.}$$

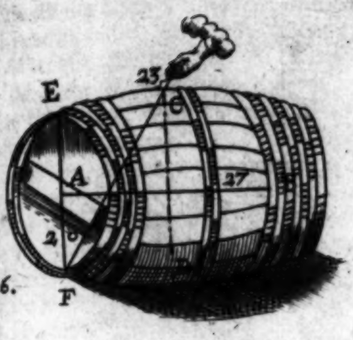
CHAP. XI.

Containing the Principles of the Art of Gunnery, in a Compendious form, with divers Conclusions both Arithmetical, Geometrical, Instrumental, and by Tables.

The Qualifications a Gunner ought to have, and his Duty, and Office.

HE ought to have skill in *Arithmetick*, to work any Proportion by the Rule of Three, to extract the Square and Cube Roots, and to be perfect in the Art of Decimal Arithmetick, and to be skilful in Geometry; that he may be able to measure heights, depths, breadths, and lengths; and to draw the Plot of any piece of ground. A Gunner that hath a Charge ought also to have in readiness all necessary things for his Artillery:

As Wheels, Axle-trees, Ladles, Rammers, Sheep-skins to make Spunges, Gunpowder, Shot, Tampions, Chain-shot Cross-bar-shot, Parchment, or Strong Paper to make Cartrages, Fire-works, Artificial Torches, Dark Lanthorns; again, (to Mount and dismount, Guns,) Hand-spikes, Coyns, Budge-Barrels to carry Powder, and Baskets to carry Shot to your Piece. When leisure will permit, he is to choose good Match to arm his Linstocks in readiness for to give fire, and also a pair of Caleper Compasses to measure the Diameters of Shot, or the Muzzel, or Base-ring of a piece, or the like; and also



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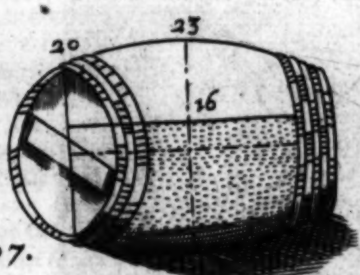

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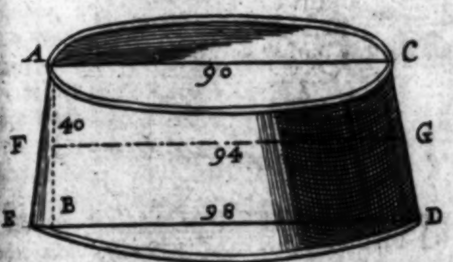
The Tun.



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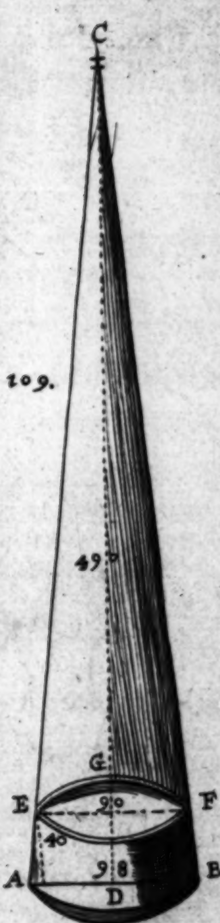

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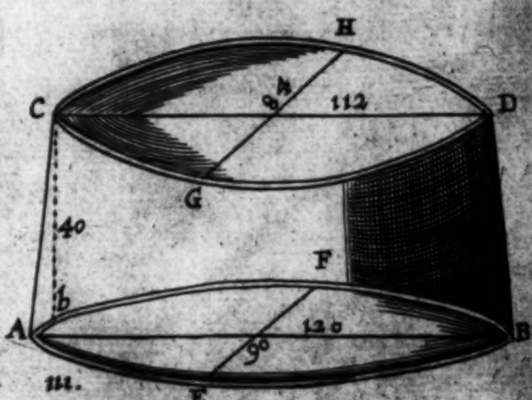

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Chap

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alſo a ſmall Braſs pair of Scales and weights, a Ruler divided into Inches, of 8 or 10 Parts in every Inch, for the ready meaſuring of Cartrages, and how to fill them.

A Gunner ought to know the Names, Length, Weight and Fortification of every Piece about the Chamber (that is as far as the Piece is laden with Powder); and be able to tell readily how much Powder is a due Charge for any Piece, what Shot is fit, how many Matroſſes muſt attend the ſame, how many Horſes or Oxen will draw the ſaid Piece, or Men, if occaſion be. He muſt be careful in making choice of a ſober honeſt Man for the Yeoman of the Powder; and he muſt not beat up the Head of his Powder-Barrels with an Iron Tool, but with a Wooden Mallet, which can never fire the ſame: A Gunner ought to try his Piece, to know whether it be true bored or not, to proportion his Charge according to the thinneſt ſide of the Metal, and accordingly take his direction at the Britch of the Piece, juſt over that place where by Art he finds the middle of the Bore is within the Piece; by which means a good Shot may be made out of a bad Piece.

Before he makes a Shot, he is to conſider, that if the Piece lie point plank, or under Metal, he ought to put in a ſufficient Wadd after the Shot, to keep it cloſe to the Powder; for if it ſhould not be cloſe, the Piece will break in the vacant place; but in caſe you mount your Piece, put no Wadd after the Shot.

And one chief thing is to know very well how to diſpart his Piece, be it either true bored, or not true bored, which he may try firſt.

When a fit Man is entertained, the Maſter-Gunner (whom he ſerves) ſhould bring him to his Pieces, and give him the Denominations of his Piece, and parts thereof: which when he hath learned, which is the Baſe-ring, and Trunnion-ring, the Muzzel-ring, and the like, (you may ſee their names in the Figure of the Gun without more words); and likewiſe the Crows, Handſpikes, the Coyn, and the like; and how far in the Bore is called the Chamber of the Piece: Theſe things underſtood, he may give them further directions; it is pity that the Gunners at Sea did not exerciſe the Sea-men in this knowledge, as the Corporal doth in exerciſing of them with their Muſquets; for want of this knowledge the greateſt part of common Seamen are ſo dull and ignorant, when they be required to ſtand by a great Gun in time of Fight.

Firſt Inventors of Gun-powder, and ſome Principles of Philoſophy fit to be known.

Some *Italians* have writ that *Archimedes* the Philoſopher was the firſt Inventor of Guns and Gun-powder: Or whether this be truth or not Learned Men are of divers Minds; *Munſter*, and *Gilbert Cognot* have written, that Guns were deviſed firſt in the Year 1370 by a Monk, whom *Munſter* calls *Bertholdus*; but our Country-man Dr. *Dee* in his Mathematical Preface, that an Engliſh-man was firſt Inventor of Gun-powder in another Country, and they firſt made uſe of it from him: alſo our Engliſh Chronicles do report, that in the Year 1380 a Monk did accidentally let fall a ſpark of Fire upon Brimſtone and Salpeter beaten to Powder in a Morter covered with a Stone, he ſeeing this mixture blow off the Stone from the Morter, did thereupon deviſe a kind of Powder, and taught the *Venetians* how to uſe the ſame in Pipes of Iron.

Every Simple Body is either Bright and Light, or elſe Groſs and Dark, and Ponderous, and according to the variety and difference, it is always naturally carried towards ſome one or other part; the World hath height as upwards, or depth as downwards.

All pure and rare bodies aſcend, as the Fire more than the Air; but the thick and groſs bodies deſcend, as the Earth more than the Water.

Nothing worketh naturally, but in that which is contrary to it, and more feeble; the form of working, is aided by the Qualities; and the matter ſuffering, which ſuffereth by the Quality.

Nature is extremely curious, as well of her Perfection, as her Conſervation; and then when all things conſpire, as well the Action that cometh from the Agent, as the Paſſion from the Patient, hath proportion.

Accident hath its variety from the ſubject, and goeth not from one thing unto another.

Every Corporeal thing repoſeth in its natural place; Nature admitteth no Empreſs.

A body rarifying it ſelf, the place thereof increaſeth as the body increaſeth; the reſiſtance of the moved proportional to the Mover furthereth the motion; the longer the Chace of a Piece, the louder the Report; the force of the ſtroke of a Shot dependeth on the ſwiftneſs of its motion.

The Description and Use of the Gunners Scale, upon which is all sorts of Ordnance, from the Canon to the Base, their Weight, Lading, Shot, and other things appertaining to them.

This Scale is made according to the Diameter of our English Ordnance, 8 inches long, being the Diameter of a Canon-Royal; and it may be made of Silver, Brass, or Box, or any other fine-grained Wood, that will not warp. Upon one side are set the Names of all sorts of Ordnance, and in the Angle of meeting with the Names, is the Diameter of the Bore; and in the Angle of the Step is the common length of such Pieces; and upon the edg of the Step is how many Paces these Pieces shoot point blank, and joyning to the Line of the Diameter of the Piece, in their respective Columns is the weight of the Gun, the breadth of the Ladle; the length thereof; the weight of the Charge in Powder; the Diameter of the Shot; the weight of the Shot: And then a Line of Inches; each Inch divided into 10 parts, and likewise into 8 parts, unto which the Lines of the Diameters of the Bore are extended, also on the edg of the Rule there is a Line of Numbers, by which you may work many useful Questions in Gunnery, as you will find in the following Pages.

The use of this side of the Scale. Suppose you come to a Piece of Ordnance, and it is desired to know what Piece it is, take the Scale, and put it into the Bore of the Piece, the step that fits it tells you the Name of the Piece, underneath you have the common weight of the Piece, the breadth and length of the Ladle, weight of Powder, Diameter of Shot, and weight thereof.

For Example. Admit I came to a Gun, and found by the former Directions, that her Diameter of the Bore is $4\frac{1}{4}$ Inches. And I find her Name is *Demi-culverin*, lower than ordinary; and 9 or 10 Foot the usual length, and the Paces the Piece carries point blank are 174: and the usual weight 2000 *l.* breadth of the Ladle 8, and length 12 Inches, the weight of the Powder $6\frac{3}{4}$; and the Diameter of the Shot 4 Inches, and the weight 9 *l.*

The Explanation of the Scale may serve likewise for the Table following; only take notice, that under Inches and Parts, the first figure to the left hand is Inches, and the other is so many 8 parts of an Inch.

For Example. Admit you enter the Table with a Saker of the lowest sort, the height of the Bore is $3\frac{4}{8}$ Inches, 8 Foot long, the weight 1400, breadth of the Ladle $6\frac{4}{8}$, length $9\frac{6}{8}$ Inches, weight of the Powder 3 pound 6 ounces, Diameter of the Shot $3\frac{2}{8}$, weight of the Shot 4 pound 12 ounces, and the Paces the Piece carries (by *Alex. Bianco*'s Table) is 150 of 5 Foot to the Pace.

Observe that the Ladle is but 3 Diameters of the Shot in length, and $\frac{2}{5}$ parts of the Circumference from the Canon; to the whole Culverin I allow the Charge of Powder to be about two Diameters of the Piece: From the Culverin to the Minion; the Charge to fill two Diameters and a half; all from the Minion to the Base three Diameters of Powder.

The Description of the other side of my Gunners Scale.

Upon the other side is a Scale of 8 Inches divided into four quarters, and betwixt each quarter above it is three Columns, wherein is the weight of all sorts of Iron Shot from 2 ounces to $71\frac{1}{4}$ pound; and of Lead from 3 ounces to 106 pound $\frac{1}{2}$, and of Stone from 1 ounce to $26\frac{3}{4}$ pounds; each distinguished from the other by their Names, written in the first Inch, and the weights and measures, accommodated unto our English *Averdepois* weight of 16 ounces to the pound, and to our Foot of Assize of 12 Inches to the Foot. The Line of Inches being likewise divided into 10 parts, the whole into 80, may serve for Protraction. There is also the Gunners Quadrant divided into 90 deg. in the outmost Limb, and in the 2*d* Limb within, it is divided into the 12 points of the Gunners Quadrant, and each point into 4 parts; and in the third Limb is a Geometrical division of right and contrary shadows, for the ready taking of heights and distances; and there is also a Geometrical Quadrat, with each side divided into 10 parts, and each 10 parts divided into 10 more. The use thereof in taking of heights and distances is in the 16 Chap. of the second Book of the Description of Instruments: But the use to level, or else to mount or imbase any piece of Ordnance, is in the latter part of this Book. To the side thereof is fitted a piece of Brass of the same breadth as the Scale in thickness, with two holes within an Inch of each end, and two Screws fitted to serve the four holes, as you may see in the Figure, that if you would level or mount any Piece of Ordnance, screw the Plate to the end at B, with both Screws, and put the Plate in the bottom of the Mettal as far

as he will go, and put the Tomping in upon him to keep the Plate fast, and then level and mount your Piece, as is hereafter directed: But if you will imbase any Piece of Ordnance, you must screw the Plate to the end A, and let the side with the Line of Numbers be next the Muzzle, and stop it with the Tomping, as before; then imbase your Piece, or put him under the Line of Level as you will, to what degree you please; and when you have done, screw the Plate to the side A B, with a Screw at one end, and a Screw at the other. There is also over the weight of the Shot a division of the right Ranges, and dead Ranges of Randoms of any Piece of Ordnance, upon any mounture from 0 degrees to 90 degrees. There is also a Plain Scale, on which there is a Line of Chords, with the Gnomon-line, and a Line of six hours of the same Radius, and a Line of Rhumbs with the Line of Sines; and this is for the making any Dial in any Latitude by the following Directions, and also for the making any Triangle, or resolving any Question in Navigation, or Astronomy. There is also a Brass Pin in the Center at C, for to hang the Thread and Plummet on.

The Names of the pieces of Ordnance.	Diameter of the Bore. Inches. Parts. [8	Length of the Gun. Feet. Inches. [8	Weight of the Gun in pounds. Pounds.	Breadth of the Ladle. Inches. Parts. [8	Length of the Ladle. Inches. Parts. [8	Weight of the Powder. Pounds. Ounces.	Diameter of the Shot. Inches. Parts. [8	The weight of the Shot. Pounds. Ounces.	The Piece shoots point blank. Paces.
A Base.	1 : 2	4 : 6	200	2 : 0	4 : 0	0 : 8	1 : 1	0 : 5	60
A Rabanet.	1 : 4	5 : 6	300	2 : 4	4 : 1	0 : 12	1 : 3	0 : 8	70
Fauconets.	2 : 2	6 : 0	400	4 : 0	7 : 4	1 : 4	2 : 2	1 : 5	90
Faucons.	2 : 6	7 : 0	750	4 : 4	8 : 2	2 : 4	2 : 5	2 : 8	130
Ordinary Minion.	3 : 0	7 : 0	75/80	5 : 0	8 : 4	2 : 8	2 : 7	3 : 4	120
Minion of the largest size.	3 : 2	8 : 0	1000	5 : 0	9 : 0	3 : 4	3 : 0	3 : 12	125
Saker the lowest sort.	3 : 4	8 : 0	1400	6 : 4	9 : 6	3 : 6	3 : 2	4 : 12	150
Ordinary Sakers.	3 : 6	8/9 : 0	1500	6 : 6	10 : 4	4 : 0	3 : 4	6 : 0	160
Sakers of the oldest sort.	4 : 0	10 : 0	1800	7 : 2	11 : 0	5 : 0	3 : 6	7 : 5	163
Lowest Demiculverin.	4 : 2	10 : 0	2000	8 : 0	12 : 0	6 : 4	4 : 0	9 : 0	174
Ordinary Demiculverin.	4 : 4	10/11 : 0	2700	8 : 0	12 : 6	7 : 4	4 : 2	10 : 11	175
Elder sort of Demiculverin.	4 : 6	½ :	3000	8 : 4	13 : 4	8 : 8	4 : 4	12 : 11	178
Culverins of the best size.	5 : 0	10/12 :	4000	9 : 0	14 : 2	10 : 0	4 : 6	15 : 0	180
Ordinary Culverin.	5 : 2	1½ :	4500	9 : 4	16 : 0	11 : 6	5 : 0	17 : 1	181
Culverin of the largest size.	5 : 4	0	4800	10 : 0	16 : 0	11 : 8	5 : 2	20 : 0	183
Lowest Demicanon.	6 : 2	11 :	5400	1 : 4	20 : 0	14 : 0	6 : 0	30 : 0	156
Ordinary Demicanon.	6 : 4	12 :	5600	12 : 0	22 : 0	17 : 8	6 : 1/0	32 : 0	162
Demicanon of great size.	6 : 6	12 :	6000	12 : 0	22 : 6	18 : 0	6 : 5	36 : 0	180
Canon Royal, or of	8 : 0	12 :	8000	14 : 6	24 : 0	32 : 8	7 : 4	58 : 0	185

The Use of the Line of Numbers on the Scale.

Knowing the weight of one Bullet, to find the weight of another Bullet, the height being given.

A Bullet of Iron of 6 Inches height weigheth 30 *l.* what will the like Bullet of 7 Inches Diameter (or height) weigh?

Extend the Compasses from 6 Inches to 7 Inches Diameter, the same distance will reach from 30 *l.* weight, turned three times over, unto 47 *l.* 10 ounces, the weight of a Shot 7 Inches high.

The Arithmetical way.

$$\frac{30 \times 343}{216} = 47\ l.\ 10\ \text{ounces}\ \tfrac{1}{4}.$$

That is, Cube 6 makes 216, and Cube 7 makes 343; then by the Rule of Proportion multiply 343 by 30, the Product is 10240, divide by 216, the Quotient is 47 pound, 1/4 which is 10 ounces.

By the Tables of Logarithms.

The Logarithm of 6 is ——————————0778151 2
The Logarithm of 7 is ——————————0845098 0

Subtract the uppermost Number out of the lower, the diff. increasing, 0669468
3

The triple of this difference is ——————2008404
Added to the Logarithm of 30 *l.* ——————1477121 2

Gives the Logarithm of the weight 47$\frac{64}{100}$ ——————16779616

Now to know how many ounces $\frac{64}{100}$ is, work thus by the Rule of Proportion.

If 100 gives 64, what will 16 ounces give? Answer, 10 ounces; so the Shot of 7 Inches Diameter weighs 47 *l.* 10 ounces or 47$\frac{64}{100}$ pound, the like way of work is with all such Questions

Admit the weight of an Iron Bullet being 30 pound, the Diameter is 6 Inches, the weight being 47 $\frac{64}{100}$ what is the Diameter.

Divide the distance between 30 *l.* and 47 *l.* $\frac{64}{100}$ into 3 equal parts, and that distance will reach from 6 Inches to 7 Inches the Diameter required on the Line of Numbers.

By the Logarithms.

The Logarithm of 30 is ——————1477121 2
The Logarithm of 47$\frac{64}{100}$ *l.* is ——————3677 9717

Uppermost Substracted from it, leaves the difference increasing——2008505

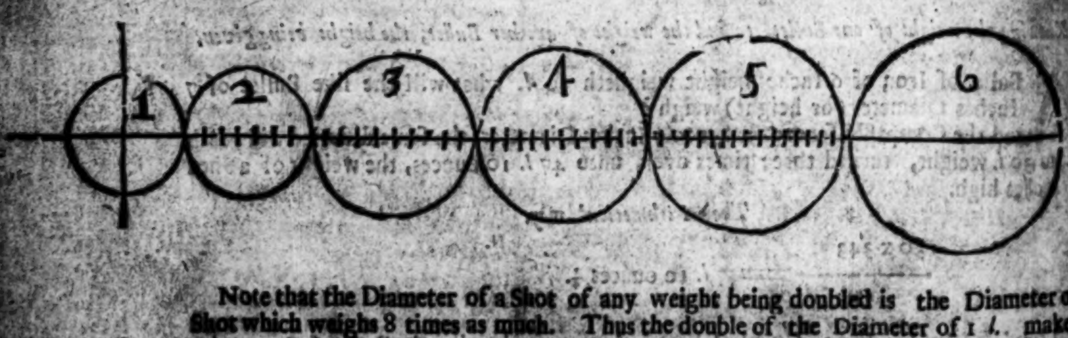
The difference divided by 3, or the third part of this difference——0669501
Added to 6 Inches Diameter, the Logarithm——7781512

Gives the Logarithm of 7 Inches Diameter required——————0845101 3

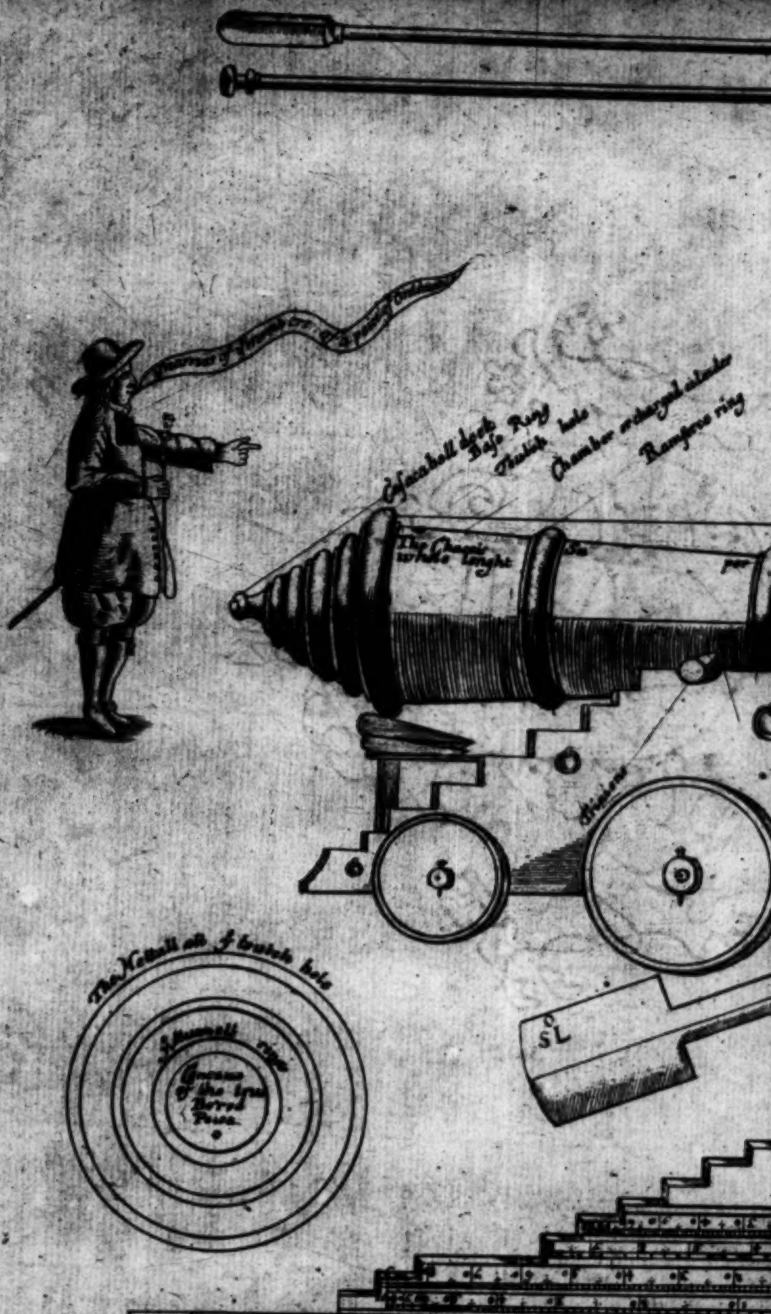
The Geometrical finding the Diameter for the weight of any Shot assigned.

This Rule shews the proportion of the Diameters according to any weight given, as having a Shot of one pound, 2 pound, or 3 pounds weight of Metal or Stone assigned; if it be of one pound, divide the Diameter into 4 equal parts, and five such parts will make a Diameter for a Shot of the said Metal or Stone that shall weigh 2 *l.*

And divide the Diameter of a Shot that weighs 2 *l.* into 7 equal parts, and 8 such parts will make a Diameter for a Shot of 3 *l.* weight; And divide the Diameter of a Shot of 3 *l.* weight into 10 equal parts, and 11 such parts will make a Shot for 4 *l.* weight. And divide the Diameter for a Shot of 4 *l.* weight into 13 parts 14 such parts will make a Diameter of a Shot for 5 *l.* weight; into 16 equal parts, 17 such parts will make a Diameter for a Shot that will weigh 6 *l.* and so dividing each next Diameter into 3 equal parts more than the next lesser was divided into, and it will with one part added give the Diameter of a shot that will weigh 1 *l.* more; and this is near the truth, being only Mechanical.



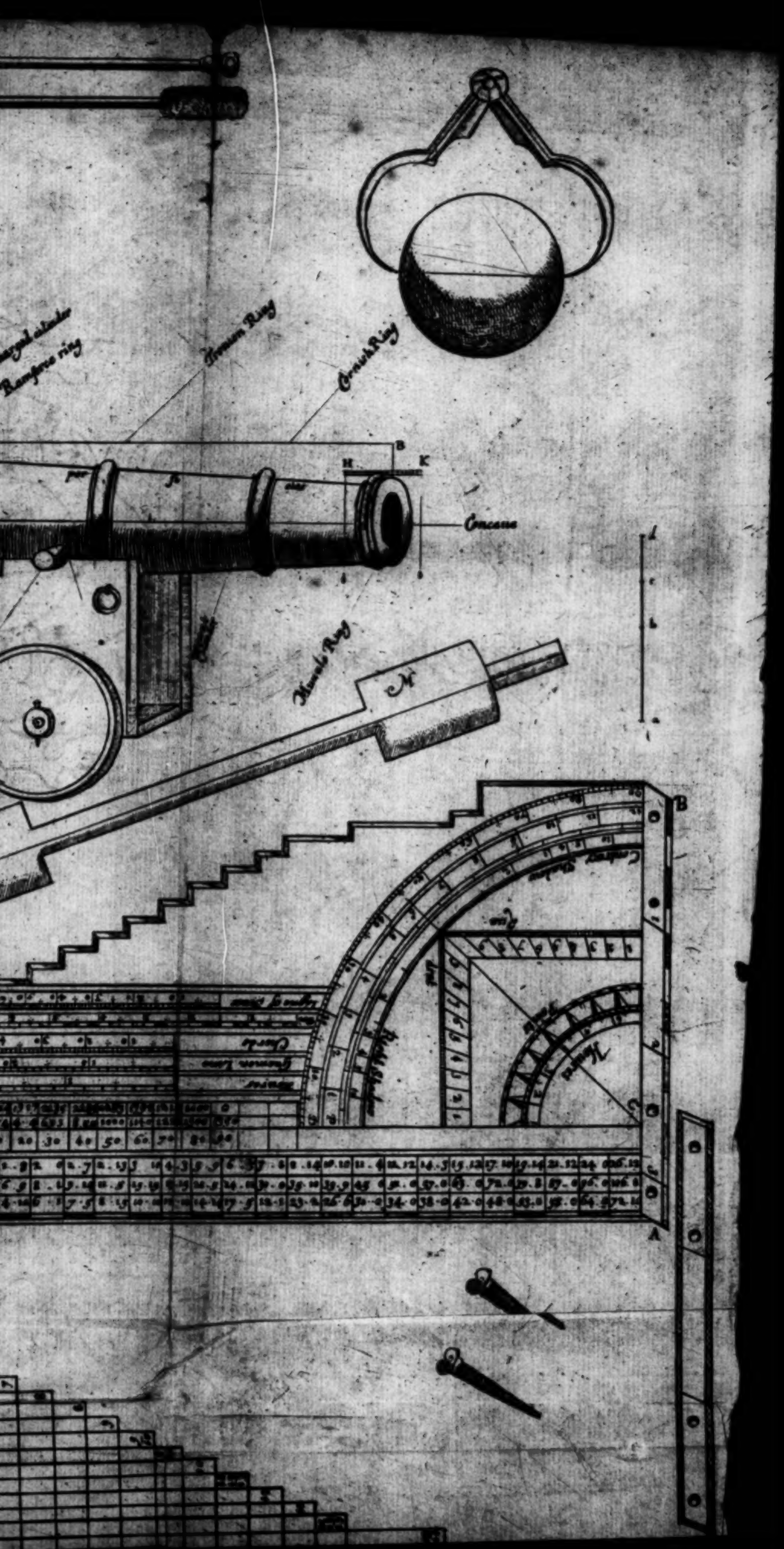
Note that the Diameter of a Shot of any weight being doubled is the Diameter of a Shot which weighs 8 times as much. Thus the double of the Diameter of 1 *l.* makes a Diameter of a shot of 8 *l.* and so the double of the Diameter of a Shot of 2 *l.* makes the Diameter of a Shot of 16 *l.* that is 8 times 2 *l.* and so the double of one of 3 *l.* make

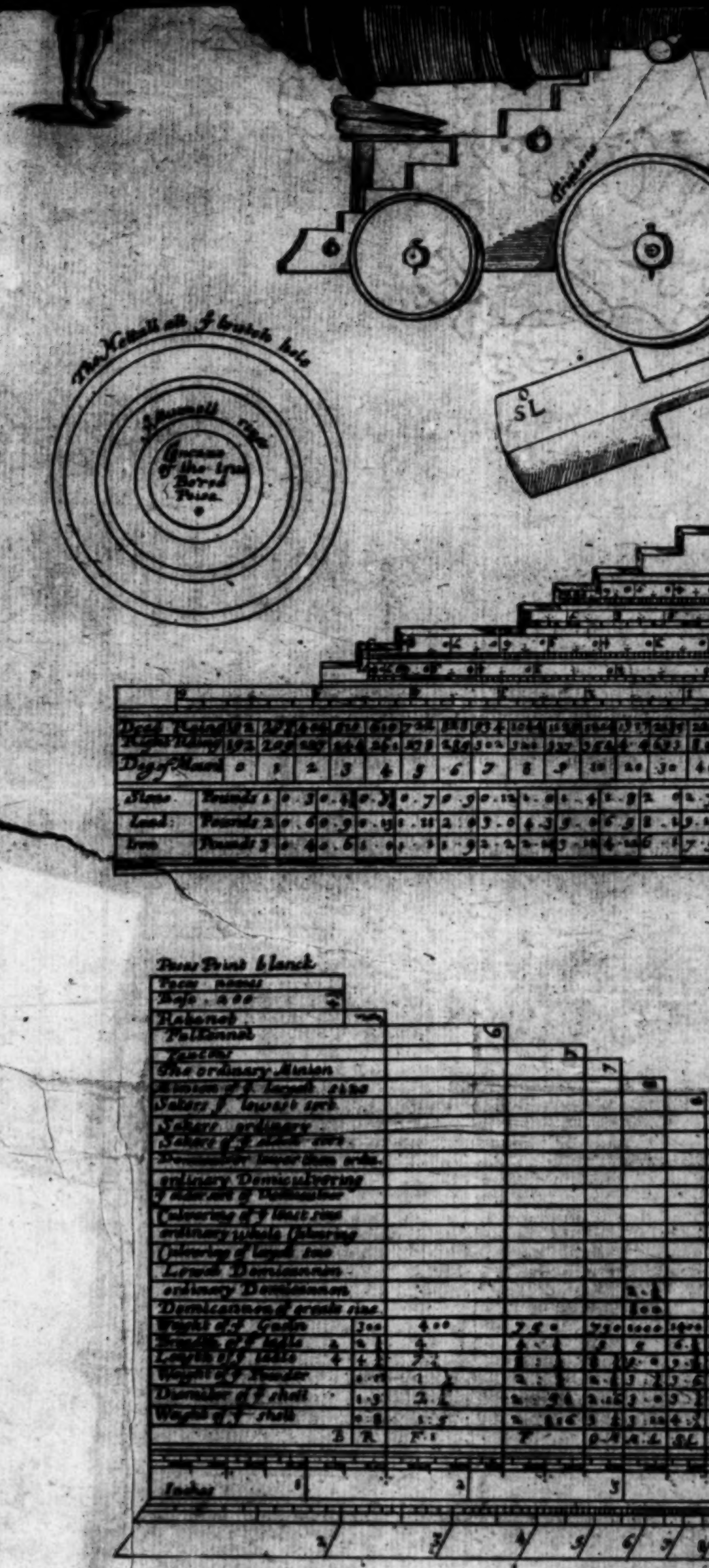


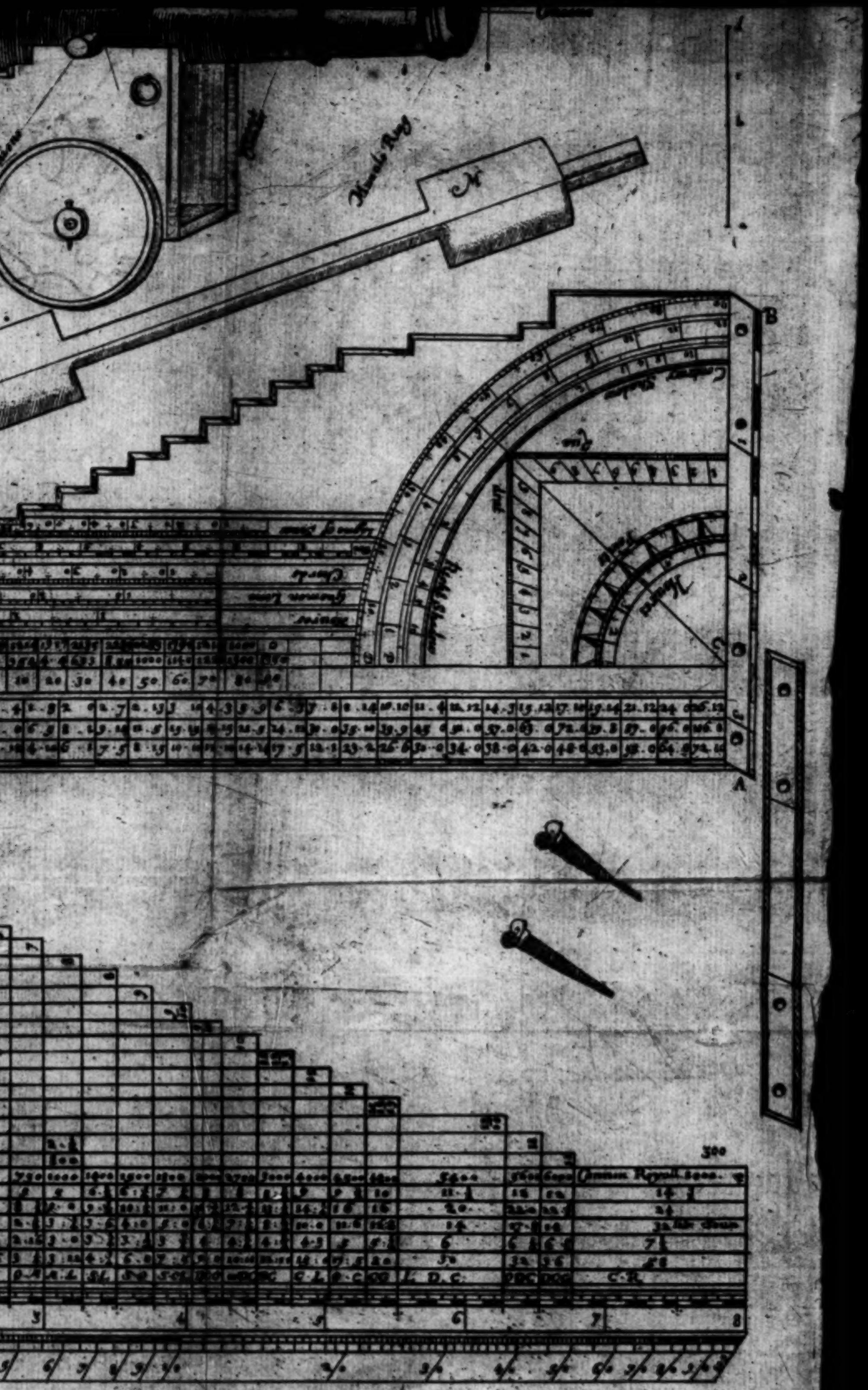
Dead Raising		[illegible]	[illegible]	[illegible]	[illegible]	610	7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Right Raising		192	209	227	244	260	278	284	302	320	337	374	[illegible]	[illegible]	[illegible]	100[illegible]
Deg. of Mount		0	1	2	3	4	5	6	7	8	9	10	20	30	40	5[illegible]
Stone	Pounds 1	0 . 3	0 . 4	0 . 5	0 . 7	0 . 9	0 . 12	1 . 0	1 . 4	1 . 8	2 . 6	2 . 7	2 . [illegible]			
Lead	Pounds 2	0 . 6	0 . 9	0 . 15	1 . 11	2 . 6	3 . 0	4 . 3	5 . 6	6 . 9	8 . 1	9 . 14	11 . [illegible]			
Iron	Pounds 3	0 . 4	0 . 6	1 . 0	1 . 1	1 . 9	2 . 2	2 . 14	3 . 12	4 . 14	5 . 1	7 . 5	8 . [illegible]			

Pecer Point blanck

Peces names	
Base . 400	4
Robonet	5
Faltonnet	6
Faulcon	7
The ordinary Minion	7
Minion of ȝ largest size	8
Sakers ȝ lowest sort	9
Sakers ordinary	9
Sakers of ȝ oldest sort	
Demiculverin lower than ordinary	
ordinary Demiculverings	
ȝ elder sort of Demiculverin	
Culvering of ȝ least size	
ordinary whole Culvering	
Culvering of largest size	
Largest Demicannon	


Reinforce ring
Trunion Ring
Cornish Ring
Concave
Muzzle Ring
B
H
K
A
C


SL
Paces Point blanck
Rabenet
Falconnet
The ordinary Minion
Sakers ordinary
ordinary Demiculvering
ordinary whole Culvering
Lowest Demicannon
ordinary Demicannon
Stone
Lead
Iron
Pounds
Inches



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the Diameter of a Shot of 24 *l.* and the double of 4 *l.* makes the Diameter of Shot of 32 *l.* and so you may proceed as you pleaſe, and find the bigneſs of any Shot.

Note alſo, having the Diameter of a Shot of 1 *l.* double that Diameter it will make a Diameter of 8 *l.* and treble the Diameter of 1 *l.* will make a Diameter of a Shot of 27*l.* and quadruple or 4 times the ſame will make a Diameter of a Shot of 64 *l.* and 5 Diameters will make a Ball of 125 *l.* and 6 Diameters of a Shot of 1 *l.* will make a Diameter of a Shot that will weigh 216 *l.*

To find what proportion is between Bullets of Iron, Lead, and Stone, by knowing the weight of a Shot of Iron; to find the weight of any other Shot of Lead, Braſs, or Stone of the like Diameter.

The proportion between Lead and Iron is as 2 to 3, ſo that a ſhot of 2 *l.* of Iron, is of like Diameter or height as 3 *l.* of Lead.

As for Example. A ſhot of Iron of 6 Inches Diameter weighs 30 *l.* to find the weight of a ſhot of Lead of the ſame Diameter.

By the Rule of Proportion. If 2 gives 30, what will 3 give; multiply and divide, and the Quotient is 45, the weight of a ſhot of Lead.

By the Logarithms.

The Logarithm of 2 is	03010300
The Logarithm of 30 is	14771212
The Logarithm of 3 is	04771212
	19542424
Log. of 45 *l.* the weight of the Shot in Lead of the ſame Diam.	16532124

Extend the Compaſſes from 2 to 30, the ſame diſtance ſhall reach from 3 to 45.

The proportion between Iron and Stone is as 3 to 8; ſo that a ſhot of 30 *l.* of Stone is as big as the like ſhot of 80 *l.* of Iron; and 11 *l.* $\frac{1}{4}$ of Stone is of the ſame Diameter 6 Inches, as a ſhot of 30 *l.* of Iron, and 45 *l.* of Lead; the porportion between Lead and Stone is as 4 to 1; ſo that a ſhot of Lead of 40 *l.* is of the ſame height as a Stone ſhot of 10 *l.*

The proportion between Lead and Braſs is as 24 to 19.

The proportion between Iron and Braſs is as 16 to 18.

By theſe Rules aforegoing you may Calculate with eaſe, if Iron ſhot be wanting, and the other to be had, what weight any ſhot of Lead, Braſs, or Stone is to fit any Piece of Ordnance; and by the ſame Rules here is a Table Calculated and doth ſhew the weight of any ſhot of Lead, Iron, and Stone, from 2 Inches Diameter to 8 Inches and quarters of Inches; the proper Stone for this purpoſe is Marble, Pebble, Blew hand Stone; (there may be a little difference of weight in ſome ſort of Stone: but theſe do nearly agree in weight;) you muſt remember in loading your piece with a ſhot of Stone you muſt not have ſo much Powder as you do with Iron ſhot, but abate according to the proportion that is between Stone and Iron.

How by knowing the weight of one Piece of Ordnance to find the weight of another Piece being of the ſame ſhape and fortification, and of the ſame Metal or any other Metal.

Firſt, with a pair of Callipers take the greateſt thickneſs of the Piece whoſe weight is known, at the Baſe-Ring; and alſo the Piece, whoſe weights you know not.

Example. Admit a Braſs Saker of 1900 weight, hath his greateſt thickneſs 11$\frac{1}{4}$ Inches; Now I find the Diameter of the other Braſs Piece whoſe weight I know not, to be 8$\frac{3}{4}$: Then proceed thus.

As the Logarithm greateſt Diameter 11 $\frac{1}{4}$	006069
The Logarithm of the leaſt, 8 $\frac{3}{4}$	094200
The Difference increaſing	11869
	3
The triple of this Difference Subtract	35607
From the Logarithm of the weight given 1900	327875
Reſt the Logarithm of 836, the weight required,	2,92228

111 Or

Or extend the Compasses from 11$\frac{1}{3}$ to 8$\frac{7}{16}$ Inches Diameter, the same Distance will reach from the weight given 1900 Pound turned three times over to 836 Pound.

The use of the Table, to find the weight of any Shot of Iron, Lead, or Stone from 2 to 8 Inches Diameter.

Inches.	Quart.	Iron. Poun.	Iron. Ounc.	Lead. Poun.	Lead. Ounc.	Stone. Poun.	Stone. Ounc.	Inches.	Quart.	Iron. Poun.	Iron. Ounc.	Lead. Poun.	Lead. Ounc.	Stone. Poun.	Stone. Ounc.
2		1	1	1	10$\frac{1}{2}$	0	7	5		17	05	26	2	6	8
2	1	1	9	2	6	0	9	5	1	20	1	30	2	7	8
2	2	2	2	3	3	0	12	5	2	23	2	34	11	8	11
2	3	2	14	4	5	1	1	5	3	26	6	39	9	9	14
3		3	12	5	10	1	7	6		30	00	45	00	11	04
3	1	4	12	7	2	1	13	6	1	34	00	51	00	12	12
3	2	6	0	8	15	2	4	6	2	38	00	57	00	14	04
3	3	7	5	11	00	2	12	6	3	42	00	62	00	15	12
4		8	15	13	07	3	6	7		48	00	72	00	18	00
4	1	10	10$\frac{1}{2}$	16	0	4	0	7	1	53	00	79	08	20	00
4	2	12	10$\frac{1}{2}$	18	15	4	12	7	2	58	00	87	00	22	12
4	3	14	14	22	5	5	9	7	3	64	00	96	00	24	00
								8		71	08	106	8	26	10

This Table is exactly Calculated, and the use thereof is very easie; we will make it plain by two Examplee; I would know the weight of a Shot of 6 Inches, in Iron, Lead, and Stone: The first Column is Inches, the second quarters of Inches, the third Pounds and Ounces of Iron, fourth Pounds and Ounces of Lead, fifth Pounds and Ounces of Stone.

Enter the Table with 6 Inches Diameter in the first Column, and in that Line you shall have 30 pounds of Iron, 45 pound of Lead, 11 pound 4 Ounces of Stone, and likewise for Inches $\frac{3}{4}$ Diameter the weight of an Iron shot is 14 Pound 14 Ounces, of Lead 22 pound 5 ounces, of Stone 5 pound 9 ounces; and so of the rest.

The Arithmetical way.

$$\frac{C\,8\frac{1}{4} \times 1900}{G\,11\frac{1}{3}} = 836\ l.\ \text{weight in Brass.}$$

But if the Piece had been Iron, whose weight you sought, you must do as before with the Brass, and find the difference of their Metals by the last Problem, which is as 16 to 18, then say by the Tables,

As the Logarithm of 18	125527
Is to the Logarithm of weight in Brass 836	292220
So is the Logarithm of 16	120412
	412632
To the Logarithm of the weight in Iron 743	287105

Or extend the Compasses from 18 to 836 the same distance will reach from 16 to 743 l. weight in Iron.

The Arithmetical way.

$$\frac{X\,836 \text{ by } 16}{18} = 743\ l.\ \text{of Iron.}$$

How by knowing what quantity of Powder will load one Piece of Ordnance; to know how much will load any other Piece whatsoever.

Admit you have a Saker of three Inches three quarters bore, and it requires 4 pound of powder; what will a Demi-Canon of 6$\frac{1}{4}$ Inches require; Work as follows.

As

As the Logarithm of $3\frac{75}{100}$ Diameter ——————— 257403
The Logarithm of $6\frac{50}{100}$ Inches Diameter ——————— 281291
the difference increasing, ——————— 23888
——(3
The triple of the difference added——————— 71664
The Logarithm of 4 the Powder, ——————— 060206
to the Logarithm of $20\frac{83}{100}$ *l.* of Powder——————— 131870

So that the Demi-Canon must have 20 *l.* $\frac{83}{100}$ or 13 Ounces for her Charge of Powder. By the Scale, extend the Compasses from $3\frac{75}{100}$ to $6\frac{50}{100}$ Inches Diameter, the same distance turned three times over from 4, will reach to 20 $\frac{8}{10}$ *l.*

How to make a Shot of Lead and Stone, the Stone being put in the Mould in which the Leaden Shot should afterwards be cast, to be of the like Diameter and Weight as an Iron Shot is of.

Inches.	Quart.	Lead. Poun.	Lead. Ounc.	Stone. Poun.	Stone. Ounc.	Both together. Poun.	Both together. Ounc.
1		0	$1\frac{2}{3}$	0	$0\frac{1}{3}$	0	2
1	$\frac{1}{2}$	0	$6\frac{1}{4}$	0	$1\frac{1}{4}$	0	8
2		0	14	0	4	1	2
2	$\frac{1}{2}$	1	12	0	8	2	4
3		3	2	0	10	3	12
3	$\frac{1}{2}$	5	7	1	0	5	0
4		7	0	1	8	8	15
4	$\frac{1}{2}$	10	8	2	2	12	10
5		14	7	2	14	17	5
5	$\frac{1}{2}$	19	4	3	12	23	0
6		25	0	5	0	30	0
6	$\frac{1}{2}$	32	0	6	0	38	0
7		40	0	8	0	48	0
7	$\frac{1}{2}$	48	0	10	0	58	0
8		59	0	12	0	71	0

If you take 5 parts of the weight of the Iron Shot in Lead, and one part Stone, it will come near the matter. Here you have a Table how much Lead, and how much Stone must be together to make them equal to Iron Shot, from 1 Inch to 8 Inches Diameter.

The Arithmetical way.

$$\frac{C\,6\frac{5}{10} \times 4}{3\frac{75}{100}\,C} = 20\ l.\ 13 \text{ ounces of Powder for to load a Demi-Canon.}$$

You are likewise to understand that the Demi-Canon should be fortified as well as the Saker, therefore find the weight of the Demi-Canon as in Sect. 8. the weight of the Saker being 1600 *l.*

The Diameter of the Saker is $3\frac{75}{100}$ Inches——————— 257403
The Demi-Canon Diameter is $6\frac{50}{100}$ Inches. 281291

The difference increasing, ——————— 23888
——(3
The triple of the difference by (3)——————— 71664
Added to the Logarithm of 1600 weights of Saker——————— 320412

Gives the Logarithm of 8332 the Demi-Canon,——————— 392076

But suppose the Demi-Canon to be no more than 6000 weight, then proceed thus to find the weight of Powder.

The supposed weight of the Demi-Canon 6000——————— 377815
Add the weight of the Powder, if well fortified, is $20\frac{83}{100}$—— 131869

The Sum is——————— 509684
Substract the weight of the Gun well fortified 8332——————— 392074

Leaves the weight of the Powder 16 *l.*——————— 117610

Fifteen

Fifteen pound being a sufficient Charge for that Piece: Or extend the Compasses from 6000 to 8332, the same distance will reach from 20 $\frac{8}{16}$ to 15 *l.* of Powder, as before.

The Arithmetical way. 6000 x 20 pound 13 ounces.

$$\frac{6000 \times 20 \text{ pound } 13 \text{ ounces}}{8332} = 15 \text{ pound.}$$

Thus you are always to take care of over-loading your Piece, which Error many run into, when they call a Piece a Demi-Canon, they presently load her with so much as is allowed for such a Piece so named, seldom examining whether the Piece have Metal enough for such a Charge, by which mistake they endanger their own Lives, and others which stand near.

To make a true dispert of any true bored Piece of Ordnance.

Now we have found how to proportion Shot and Powder to any Piece of Ordnance true bored; before we Load and Fire, let us find the true dispert to direct the Shot to the assigned mark.

With a pair of Callipers (as in the Figure preceding) you take the Diameter of a Shot, and apply it to a Scale of Inches divided into 8 or 10 parts; so with the Calipers take the greatest thickness or Diameter of the Base Ring, and by your Scale, see how much that is; as admit that the length of the Line *a b c d*, were the Diameter of the Base Ring, then take the Diameter of the Muzzle Ring; as admit it be *a b*, then divide the difference *b d* into 2 equal parts, and one of them is the Dispert, put it upon the Muzzle of the Gun as C B, and stick it fast on the top of the Muzzle Ring with a little Pitch or Wax, and from the Base Ring at A in the Figure to the top of the Dispert at B, take aim to the mark you would shoot to; but if Callipers be wanting, take a Stick that is strait and flat, and two Strings with two Musquet Bullets at their ends, and two Loops made at the other end, the Stick being something more than the Diameter at the BaseRing, and put the Stick upon the top of the Ring at the Muzzle, as you see the Figure H K on the Gun, and put the Strings nearer and farther, until they only touch the Muzzle Ring, and mark the Stick, and put the Stick on the Base Ring, and do in like manner, and mark the Stick, and the Work will be the same, as it were taken by the Callipers, for the distance of the Notches on the Stick will give the Diameter of the Base Ring, and Muzzle Ring, and half the difference is the Dispert as before, if the Piece be true bored.

Another way to Dispert a Piece of Ordnance.

If the Piece be not Chamber-bored, take the Priming-Iron, and put it down in the Touch-hole, until it rest upon the Metal in the bottom of the bore, there make a mark on the Priming-Iron even with the Base Ring; likewise apply the Priming-Iron to the bottom of the Metal at the Muzzle, and so much higher as the Mark is which you made at the Base Ring, then the Muzzle Ring, so much is the Dispert.

How to know whether your Piece be Chamber-bored.

Dispert your Piece the first way, then with your Priming-Iron take the Dispert the last way; which done, compare it with the other Dispert first found, and what it wants (being doubled) is the difference of the Chamber from the bore of the Piece.

Admit the Dispert found is three Inches, and by this last way is but two Inches, it shews that the Chamber differs from the true bore on each side one Inch; so that if the bore of the Piece be five Inches high, the Chamber being one on each side lower, is but three Inches high: The like Observation we would always have you to make, that you may not afterwards be deceived in making Cartrages of Canvas and Paper to load the same.

How to know what Diameter every Shot must be of to fit any Piece of Ordnance, or to choose Shot for Ordnance.

Take the Diameter of the bore of the Piece, and divide it into 20 equal parts, and one of those parts is sufficient vent for any Piece, the rest of the 19 parts must be the height of the Shot; but now-a-days most Gunners allow the Shot to be just one quarter of an Inch lower than the bore; which Rule makes the Shot too big for a Canon, and too little for a Faulcon; but if the Mouth of the Piece be grown wider, then the rest of the Cylinder within by often shooting, to fit Shot to such a Piece, you must try with several Rammers-heads, until you find the Diameter of the bore in that place where the Shot useth to lie in the Piece; and a Shot of one twentieth part lower than that is fit for the Piece; therefore let Gunners remember to try the Piece as directed.

To find what Flaws, Cracks, and Honey-combs are in Pieces of Ordnance.

This is a good way, as soon as you have discharged a Piece of Ordnance, cover the Mouth of the Piece close, and stop the Touch-hole at the same time; if there be any unknown Cracks or Flaws which go through the Metal, a smoak will come through those Cracks and Flaws; if not, the Gun is sound.

There is a way to reflect the Sun-beams when he shineth, with a Looking-glass or Steel in the hollow Cylinder of the Piece; for by this means a bright and clear light will be within, and by that light you will see every Flaw, Crack, or Honey-comb.

But by this way you may see at any time; take a Stick something longer than the Piece, cleave the end of the said Stick, for to hold an end of a Candle, light the Candle, and put it into the cleft of the Stick, and put it into the Piece; by this light observe by degrees whether from the one end to the other, there be any of the foresaid Flaws, Cracks, or Honey-combs in the Piece.

This is a usual way likewise, if in striking a Piece upon several places of the Metal with a Hammer of Iron, you shall at any stroak hear a hoarse sound; then without doubt there is Honey-combs: but if in so striking the Piece, you shall at every stroak hear a clear sound, then you may be sure your Piece is clear of any Honey-combs, Cracks, or Flaws.

To find whether a Piece of Ordnance be true bored or not.

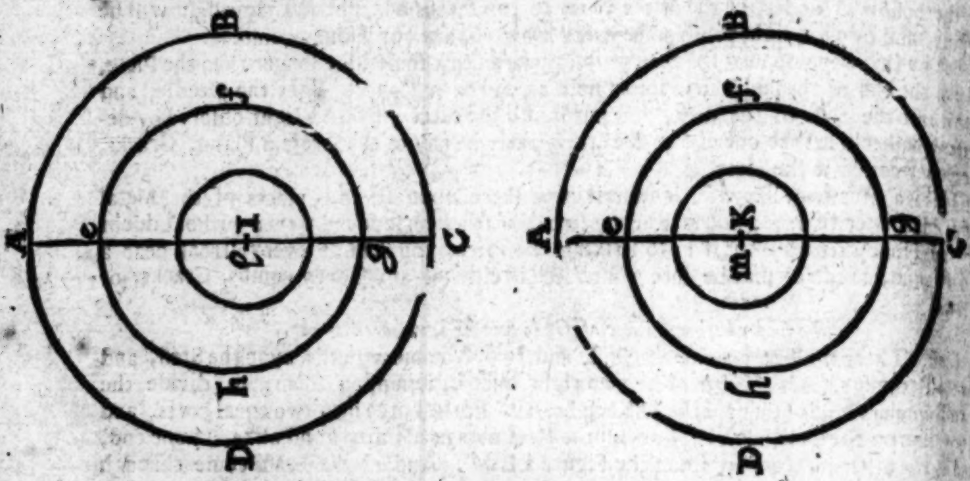
First, There must be provided a Staff, and two Rammers heads upon the Staff, and on the Rammers heads there must be two right lines drawn upon them; to divide the two Rammers heads (that are the just height, and fit the bore) into two equal parts, and draw lines on the Staff, that the lines on the Rammers heads may stand alike, at one end, and at the other end, as you see in the Figure a L M. And let the Staff come through one of the Rammers heads about nine Inches longer than the Cylinder of the Gun; then lay a flat Stick on the Muzzle Ring, and hold the side of the Quadrant (on the Gunners Scale) to the Stick, and by the String and Plummet find the middle, or upper and lower place of the Metal; then after you have found the upper and lower point of the Metal, put the Rammer head L into the Gun, and let one hold it hard, and right with the marks on the other upper and lower part of the Metal with the lines on the Rammer head above and below, whilst you put a Priming-Iron in at the Touch-hole, and striking hard on the Rammer head, make a mark; then pull it out, and apply the line on the Rammer head to the mark on the upper and lower edge of the Muzzle of the Gun, and you may presently see how much the mark is from the right line of the Rammer head, to the right hand, or to the left; that is, if the mark is just on the right line, the bore is in the midst: But if you find it a quarter of an Inch on the right, or left hand, so much lieth the bore either to the right or left; and in shooting, the Piece must be ordered accordingly.

But now to know whether it is thicker upwards or downwards, or how the bore is, the way to know this, find the Diameter to the Piece at the Touch-hole with a pair of Callippers, then bend a Wire a little at the end, that it may catch at the Metal when it is drawn out; after the Wire is fitted thus, first put it into the Touch-hole till it touch the bottom of the Metal in the Chamber; then holding it in that place, make a mark upon the Wire, just even with the Touch-hole: afterwards draw up the Wire, until it catch at the Metal at the top of the Chamber; and there make a mark upon the Wire just even with the Touch-hole: The difference between the two marks is the wideness of the Chamber under the Touch-hole, and the distance between the first mark and the end of the Wire, having half the Diameter of the Chamber of the Piece substracted from it, will leave the half of the Diameter of the Piece at the Touch-hole, if the Piece be true bored: But if this measure be more than half the Diameter, then the bore lieth too far from the Touch-hole, and the upper part of the Metal is thickest; but if it be less, the under part hath most Metal.

One Example will make it very plain.

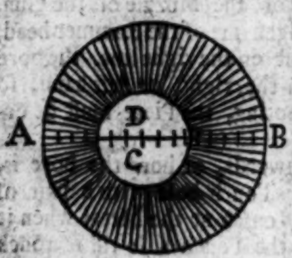
Suppose that the Metal at the Britch be represented by A B C D, and the Metal at the Muzzle by *e f g h*, and the bore of the Piece I, whose Center is *h* or the bore K, whose Center is *m*: and I find the Diameter of the Piece to be 15 Inches at the Touch-hole, the half thereof is $7\frac{1}{2}$ Inches. Then I find by a Wire the Diameter of the bore to be 5 Inches, but the bottom of the Metal is $10\frac{1}{2}$ Inches, half the Diameter of the bore being $2\frac{1}{2}$ Inches, which substracted from $10\frac{1}{2}$ Inches leaves 8 Inches, which is $\frac{1}{2}$ Inches more

more than the Diameter of the Metal, that ſhews the Centre of the bore to be at R; and the thinneſt of the Meal is undermoſt, and there is like to break firſt; beſides, it ſhews that you muſt add half an Inch to your Diſpert of a true bored Piece, to make a Diſpert for the Piece to ſhoot well: But if the bottom of the Metal had been found $9\frac{1}{4}$ Inches, then ſubſtracting $2\frac{1}{4}$ Inches, leaves 7 Inches; which is half an Inch leſs than half the Diameter of the Metal, and therefore the thinneſt part of the Metal is uppermoſt, and the Diſpert muſt be ſhortned half an Inch. View the following Figure.



To know what quantity af Powder ſhould be allowed to a Piece of Ordnance not truly bored.

Admit the Diameter of the Metal of the Piece at the Touch-hole be 16 Inches, and the Diameter at the bore is $5\frac{3}{4}$ Inches, the weight of the Piece 4850, ſuch a Piece requires 11 *l.* for her due Charge, being near two Diameters of her bore in Powder: But I find the ſoul or bore to be an Inch out of his place, or an Inch from the middle of the Metal; then I conclude, that the thinneſt part of the Metal is 4 Inches $\frac{1}{8}$ parts, and thickeſt ſide 6 $\frac{1}{8}$ parts; by which it appears, that one ſide is juſt two Inches thicker than the other ſide, as you may ſee plainly by this Figure; in which the line A B divided, is the Diameter or greateſt thickneſs at the Touch-hole, every Diviſion repreſents an Inch from the outward Circle to the outward Circle, is the thickneſs of the Metal; the inward Circle repreſents the bore of the Piece, which you may ſee is an Inch from the true bore or Centre of the outmoſt Circle; therefore you muſt work to find the weight of Powder, as if the Piece were fortified no more than only ſo much as the thinneſt part of the Metal is, which here doth appear to be 4 Inches $\frac{1}{8}$ parts, which doubled makes $8\frac{1}{4}$ to which add the Diameter of the bore $5\frac{3}{4}$ makes 14 Inches, which call the leſſer Dameter.



To find the weight of Powder proceed thus.

The Logarithm of the greateſt Diameter 16 is——————220412
The Logarithm of the leſs Diameter 14——————214612

The difference decreaſing——————5800
(3
The triple of the difference Subtracted——————17400
From the Logarithm of 11 *l.* Powder——————204139

Leaves the Logarithm of the Powder $7\frac{6}{16}$ *l.*——————186739

So that 7 pound $\frac{6}{16}$ or 6 ounces is a ſufficient Charge for ſuch a falſe bored Piece; or extend the Compaſſes from 16 to 14, the ſame diſtance 3 times repeated from 11, will reach $7\frac{6}{16}$ pound, as before.

The

The Arithmetical way.

C 14 is | 2744 x 11
——————————=7 pound 6 ounces, as before.
C 16 is | 4096.

How Moulds, Forms, and Cartrages are to be made for any sort of Ordnance.

Cartrages are usually made of Parchment or Paper ; to make them, first take the height of the bore of the Piece, and allow $\frac{1}{32}$ part of the Diameter for the Vent, and make the breadth of your Cartrages three Diameters of the Chamber of the Piece, besides the sewing or pasting, and from the Canon to the whole Culverin is allowed about two Diameters of the Piece, from the Culverin to the Minion, the Charge is the length of two Diameters $\frac{1}{3}$, and all from the Minion to the Base three Diameters of Powder, but make them at first about four Diameters long, and according to the directions here given mark them ; or put a pound of Powder into each Cartrage, and measure how full it fills it by your Scale for each Gun, and so you may know how to mark the Cartrage for the full loading, or diminishing of your Powder, according to the goodness or badness thereof, and for the extrarordinary over-heating of the Piece. Having resolved what sort of Ordnance are to serve you, accordingly have a form of Wood turned to the height of the Cartrage, which is the $\frac{1}{32}$ part of the Diameter of the bore, and half an Inch longer than the Cartrage ; before you paste your Paper on the Form, first tallow it, so will the Parchment or Paper slip off without starting or tearing ; if you make for Taper bored Guns, your Forms must be accordingly tapered ; if you make Cartrages of Parchment, allow one Inch for the Seams ; but of Paper $\frac{1}{4}$ of an Inch (more than three Diameters for the Pasting. When your Cartrages are upon the Former, having a bottom ready fitted, you must paste the bottom close, and hard round about, and then let them be well dried ; and mark every one with black or red Lead, or Ink, how high they ought to be filled ; and if you have no Scales nor Weights, these Diameters of the Bullets make a reasonable Charge for the Canon $2\frac{1}{4}$, for a Culverin 3, and for the Saker $3\frac{1}{2}$, for the lesser Pieces $3\frac{1}{4}$ of the Diameter of the Bullet, and let some want of their weight against the time they are over hot, or else you may endanger your self and others.

How to make Ladles, Rammers, or Spunges for all sorts of Ordnance.

Every Master Gunner should know how to Trace, cut out, and also make up and finish all Ladels, Spunges, and Rammers, and direct others how to make, and finish the same ready for use.

You have in the Table foregoing the length and breadth of the Ladle, answerable to each Gun in inches and parts, and you must allow half a Diameter more to inclose the head of the Staff within the Plate ; the Button or Head of the Ladle-staff must be the height of the Shot almost ; for Spunges, there bottoms and head are to be made of soft wood, as Asp, Birch, Willow, to be one Diameter $\frac{1}{4}$ in length, and $\frac{3}{4}$ or a very little less of the height of the Shot, and covered with Sheep-skins, and nailed with Cooper's Nails, that together they may fill the concave of the Piece.

Let the Head of the Rammers be of good hard Wood, and the height, (as before) one, and the length $\frac{3}{4}$ of the Diameter of the Shot at one end next the Staff, it must be so turned, that a Ferril of Brass may be put thereon, to save the Head from cleaving, when you Ram home the Shot, the Buttons or Heads must be bored $\frac{2}{3}$ for the Staff to be put in, and fastned with a Pin through and the Staffs length a Foot more than the concave of the Gun.

To make a Ladle for a Chamber-bored Piece, your Compasses opened to just the Diameter of your Chamber within $\frac{1}{8}$ part of an Inch, divide the measure into two equal parts, and with that distance draw a Circle on a Slate or Paper, and take $\frac{2}{3}$ parts of the Circumference of that Circle for the breadth of the Plate of the Ladle ; and for Cannons, the length ought to be such as at twice to hold the just quantity of Powder, Rammers and Spunges for Sea service, are made of four-strand rope, well served with Spun-Yarn that they may be stiff for use.

How the Carriage of a Piece should be made.

Measure the length of the Cylinder of the bore, and once and half that length should be the length of the Carriage, and in depth four Diameters of the bore of the Piece at the fore-end, in the middle 3 and $\frac{1}{2}$, and at the end next the ground 2 and $\frac{1}{2}$, the thickness

ness the Diameter of the shot; the wheels should be one half the length of the Piece in height; the Saker and Minion must exceed the former by $\frac{1}{7}$ part, the Falcon and Falconet by one sixth Part, Sea-Carriages are made less, and of another form.

To know if the Trunnions of a Piece of Ordnance are placed right.

Measure the length of the Cylinder of the bore from the Muzzel to the Britch, Divide the length by 7, and multiply the Quotient by 3, and the product will shew you how many inches the Trunnions must stand from the the bottom of the bore of the piece, and and you must know that the Trunnions ought to be placed, so that $\frac{4}{7}$ of the Peice may be seen above the Center of the Trunnions.

How much Rope will make Britchings and Tackles for any Piece.

The most experienced Gunners give this Rule. Look how many foot your Piece is in length, four times so much is the length of the Tackle, and their Britchings twice the length, and if the Ropes be suspected not to be good, they nail down Quoyns to the Fore-Trunks of heavy Guns, that they may have no play; and if Britchings, and Tackles, and Quoyns should give way in foul weather, presently dismount her, that is the surest way.

What Powder is allowed for Proof, and what for Action of each Piece.

For the biggest sort of Pieces, as Cannons; for Proof $\frac{4}{5}$, and for Service $\frac{1}{2}$ the weight of her Iron Shot, for the Culverin the weight of the Shot almost for Proof, and for Action $\frac{2}{3}$, for the Saker and Faulcon, for Proof the weight of the Shot, and for Action $\frac{4}{5}$, and for lesser Pieces the whole weight of the Shot, for Service and for Proof give them one and $\frac{1}{3}$ of the weight of the Bullet in Powder.

The difference between the common Legitimate Pieces, and the Bastard Pieces, and extraordinary Pieces.

Gunners call them Legitimate Pieces, that have due length of their Chase according to the height of their bores, Bastard Pieces, are such as have shorter Chases than the Proportion of their bore doth require; and Extraordinary, are such Pieces as have longer Chases, than the Proportion of their bore alloweth; and these are called Bastard Canons, Culverins; and so likewise of Saker and Faukons, which by your Scale, and the Rule thereon, you may presently find.

How Powder is made, and several ways to know whether Powder be decayed or no, by moisture or age, in part, or in whole.

Powder was always made of Salt-Peter, Brimstone, and Charcoal; but in these latter times experience hath still mended the goodness or strength of it more than it was in former times by much: The best sort that is made at this present time of six parts Salpeter, Brimstone one part, and Charcoal one part. The common Pistol Powder is now made of Saltpeter five parts, one part of Brimstone, and one of Coal; Canon-Powder of Saltpeter four times as much as of Brimstone, and as of Coal. The reason why Pistol-Powder being the strongest is not so good for the Canon as the Canon-Powder which is the weakest, although you take but so much of the Pistol-Powder as you find to be of like strength with that quantity of Canon-Powder fit for the Charge of the Piece: And the reason why Canon-Powder is best for Ordnance, is, because it taketh up a greater room in the Cylinder of the Piece than Pistol-Powder; and so it hath the greater length or fortification of Metal about it in the Piece.

This *N. Nye* found by an Experiment made by him, he loading a Saker-bore Piece of Iron, the thickness of the Metal about the Chamber was 2 Inches, with 4 pound of weak Cannon-Powder, which filled the Cylinder of the bore 9 Inches just. He fired, and the Piece went off safe; and he saith, he loaded her again with one pound and $\frac{3}{4}$ of fine Powder almost, which filled the bore but 2 Inches $\frac{1}{2}$, and when the Gun was discharged it broke into divers pieces.

How to know good Powder.

The harder the Corns of Powder are in feeling, by so much the better it is. Secondly, Gun-powder of a fair Azure or French Russet-colour is very good, and it may be judged to have all its Receipts well wrought, and the proportion of Peter well refined. Thirdly,

Thirdly, Lay three or four Corns of Gun-powder upon a white piece of Paper, the one three fingers distant from the other, and fire one, if the Powder is good, they will all fire at once, and leave nothing but a white chalky colour in the place where they were burned, neither will the Paper be touched; but if there remains a grosness of Brimstone and Saltpeter, it is not good. Fourthly, If you lay good Powder on the Palm of your hand, and set it on fire, it will not burn you. Fifthly, To know the best amongst many sorts of Powder, make a little heap of every sort, and then setting those heaps one from the other, mark well when you put fire into them, which of the heaps did take fire the soonest; for that Powder that will soonest be on fire, smoak least, leave least sign behind it is the best.

How to make excellent good Match to give fire to any Ordnance.

Take Cords made of Hemp that is not very fine, or of Tow which is better, (although it will consume sooner,) and twist it until you have made the Strands as big as a mans little Finger; this done, boyl the said Cords in strong Lye-ashes, and a little Saltpeter, until all the Lye be wasted, and then make it up, and take the Feces or remainder into your hand, and through it draw the Match twice or thrice, then dry it, and keep it for special uses, for Vaults, Mines, and most weather, for it is very fit for your use any where.

To make Powder that will not waste with time, and preserve that which is good from decaying.

That time shall not waste it, take what quantity of Powder you will, and mix it with Brandy, and make it up in Balls, and dry them well in the Sun, or in a warm place, and keep them in Earthen Pots well glazed until you have occasion to use them.

To preserve Powder that is good, all Gunners have, or should have that reason to keep their Powder and Store in as good a dry place as is to be had in Fort or Ship convenient, and every Fortnight, or at most three Weeks, turn all the Barrels, and Cartrages (barrelled up for readiness) upside down; so will the Peter be disperst into every place and part alike; for if it should stand long, the Peter will descend downwards always as it lies, and if it is not well shaked and moved, it will want of its strength at top very much, and one Pound at bottom, with long standing, will be stronger than three at the top. Keep all Cartrages which are filled for the Piece against it is hot in Barrels by themselves, that you may know them by a mark when need requires.

To renew and make good again any sort of Gun-powder that hath lost its strength by long lying, or moisture, or any other means.

First, moisten the said Gun-powder with Vinegar or fair Water, beat it well in a Mortar, and then sift it through a fine Sieve or a Search; with every pound of Gunpowder mingle one ounce of Salt-peter that hath been mealed; and when you have so done, beat and moisten this mixture again, until you see by breaking, or cutting with a Knife that there is no sign of Salt-peter in it; moreover to corn this Powder when it is incorporated with the Peter as it ought to be, prepare a Sieve with a bottom of thick Parchment made full of round holes; then moisten the Powder, which shall be corned with Water, put the same, and also a litle Boul into the Sieve; and when you have so done, sift the Powder so as the Boul rolling up and down in the Sieve, may break the clods of Powder, and make it by running through the holes to corn; and that which will not go through, you must beat it again until it will.

To make Powder of divers Colours, and first to make white Powder.

Take of Salt-peter 12 parts, of Brimstone two parts, and of Camphir one part, beat and sift, and incorporate all these things together; and after you have so done, beat them again, and so oft until you are sure they are well incorporated, then moisten it with *Aqua Vitæ*; and when you have thus done, corn the Powder, as you are taught before.

To make Red Powder.

Take the same things, and work them as before directed for White Powder, and as that was moistned with *Aqua Vitæ*, now you must moisten this with Vinegar, being first boyled with Brasil wood until it be red as blood, which will make the Powder likewise so in moistening it, and then corn it, as is before taught.

To make any coloured Powder.

Boyl the Vinegar in such transparent Colours as you would have the Powder to be of,

as if Blue, with blue Rice, of Green, with a little Verdigreaçe, and the like: Always take care that the Colour be not too thick, but very thin, or else it will weaken the Powder that you make.

Of several sorts of Salt-peter, and a way how to make a sort of Salt-peter very excellent, with ease, and less cost than any way.

Artificial Salt-peter is a mixture of many substances gotten with Fire and Water out of dry Dirt and Earth, as out of Vaults and Tombs, and also Charnel-Houses: The best of all is of Beasts Dung converted into Earth, in Stables or Dung-hills of a long time not used; and when it is to be made, it is made with a great deal of Charge. Another sort of Salt-peter is made on Flower that is called Plaster that groweth on Walls, four parts, of unslack'd Lime one part, and so boyled over the Fire with Water, and proceed as is usual in making Salt-peter. But this one way, which is the most easie and least cost I will shew you.

Take quick Lime, and pour warm water upon it, and let it stand six days, stirring it twice or thrice a day; take the clear of this water, and set in the Sun until it be wasted, and the Salt-peter will remain in the bottom. To refine Salt-peter, and make it fit for use, there is several ways,but this by Fire I shall only write of. Do thus; take an Iron Pot or Skillet and fill it with Peter, set it on the Fire, and cover it close with an Iron Cover, or with a Stone; when the Salt-peter is melted, take Brimstone most finely beaten, and cast some thereon; kindle it, and let it burn until all the upper part be burned, which leave the Salt-peter close like to a piece of Marble, for the Brimstone will burn up the greasiness of the Salt-peter. It is no purpose to give further relation of this, by reason every Gunner may have his Peter ready made, refined, and in Meal at the Ship-Chandlers; or if he is constrained to make Peter or Powder, he may have several Books which give a full and large Description of the making thereof.

How to load and fire a Piece of Ordnance like an Artist.

To load your Piece, first observe the Wind, and be sure to lay your Budge-Barrel, or Cartrage of Powder to Windward of your Piece, and place your Linstock to Leeward, clear the Touch-hole, and Spunge her well, and strike the Spunge on the Muzzle to shake off the foulness, two or three blows. Stand on the right side of the Gun, and let your Assistant hold the Barrel aslope, so that you may thrust in the Ladle, being full, give it a shog, then strike off the heaped Powder, he being on the right side likewise, with your Body clear of the Muzzle, put the Ladle home to the Chamber, steadily holding your Thumb upon the upper part of the Ladle Staff, then turn the Staff until your Thumb be under it, and give a shake or two to clear the Powder out of the Ladle; as you draw it out, keep it up that you may bring no Powder out with the Ladle; then with the Rammer put the Powder home gently, and after put in a good Wad, and thrust it home to the Powder, and give it two or three stroaks, to gather the loose Powder together, and it will fire the better; be sure your Assistant have his Thumb on the Touch-hole all the while; then put in the Shot home with the Rammer, and after it another Wad, and then with the Rammer give two or three stroaks more to settle it home, that there may be no vacuity between the first Wad, Bullet, and last Wad; standing to Windward, and your Piece (by the Dispert) directed to the mark, prime her, and let the Powder come from the Touch-hole to the Base Ring, your Leg standing forward, and and fire the Powder on the Base Ring, and draw back your hand, and you have fired like a Gunner; but if you had given fire upon the Touch-hole, the Powder there would have endangered to have blowed the Coal and Linstock off your hand; therefore you must have a care of a great Touch-hole.

The difference of Shooting by the Metal, and by a Dispert.

Shooting by the Metal, as in the Figure A B, is thus, admit you raised the Muzzle Ring, and the Base Ring, and the Mark with your Eye in a right line, if you put the Gunner's Scale into the Muzzle with the Plummet hanging to it, you shall find it elevated, which will be more or less according to the length of the Piece, and in regard of the several differences of the length and Diameter of her Base and Muzzle Ring, no certain proportion can be assigned for the Randoms, but they vary according to the length of the Piece.

How

How to direct a Piece, to amend an ill shot that was made by a Dispert.

After you have made one Shot, and find the Piece carry just over the Mark, then load your Piece as hath been before taught, and when your Piece lies directly against the Mark, observe how much the last stroke of the Shot appears above the Mark, so much longer make your Dispert, that the top of it may be just seen from the Britch of the Piece in a direct line with the stroke of the Shot; and then level your Piece with this new Dispert to the assigned Mark, give fire, and it may prove a good Shot, if the first Shot had struck under the Mark, then bring the Piece in all points as before; mark how much the Dispert is over the Shot, and cut it just so short, as being at the Britch, you may discern the top of it, the Mark of the Base Ring, and stroke of the Shot in a right line, when you perceive it is of such a length, level the Piece to the intended Mark, as at the first, prime, and give fire.

If the first Shot had struck on the right hand of the Mark, to mend it you must level the Piece as formerly, you standing behind the Britch of the Piece, observe the stroke of the Shot over the Dispert, and what part of the Base Ring you saw in a right line with the Dispert, and the stroke of the Shot, set up a Pin with a little soft Wax there on the Base Ring, then level your Piece to the Mark intended by this Pin, and the first Dispert, and you may make a fair shot; for when you level by the Metal of the Base Ring, where the Pin is placed and the Mark; look over the top of the Dispert from the Mark in the Base Ring, and you shall find the Piece to lie just so much to the left, as the former Shot struck to the right from the intended Mark, which should in all likelihood prove a good Shot, unless there be some other impediment.

But if the Shot be both wide and too low, then you must use both Directions, as before taught to make the next Shot; first regulate the Dispert by cutting it shorter, according as the Mark of the Shot is lower than the intended Mark, then by the last Rule mend the shooting wide; these things done with care and diligence, you may be sure will mend a bad shot.

Of Shooting by Elevation or Random at a Mark.

The Random of a Piece is the whole distance from the Platform upon which the Piece is discharged unto the first fall or graze of the Bullet on the level line; or on the ground called the Horizontal Plain. Now it is very difficult, and a thing uncertain to arrive herein unto exactness without much experience of the Piece; and therefore every one that will learn to shoot at Random, must draw his Piece into a level ground, where first shooting level, he must observe that distance in Feet and Paces; then mount his Piece to one deg. and mark where that doth graze, and thus find the distance of every degree from the Level to the tenth degree, or as high as the Piece will mount; and by these distances make a Table, to which annex the degrees against the distances, by which Table, and the Rule of Proportion, you may find how far another Piece will convey her Shot from degree to degree; but in case you cannot have the Liberty, nor Powder to do that, you shall have a Table here that was made out of a Saker eight Foot long (by *Nath. Nye*, as in the fortieth Chapter of his Book) where he saith, he loaded her with three pound of Powder, the Shot at one degree of mounture was carried 325 Paces; the next Shot was at five degrees Random, and that mounture the Shot was conveyed 416 Paces; and the next trial was at seven degrees mounture, and the Random was 505 Paces; the last trial was at ten degrees mounture, which sent the Shot 630 Paces, of five Foot to a Pace.

Whilst he made these Shots, he loaded the Piece himself with loose Powder, exactly weiged, and weighed the Wad also, and beat down the said Wad with four strokes so near as he could by the same strength, as he did the time before; also he let the Piece cool betwixt each Shot of it self, staying above half an hour betwixt each Shot, he put no Wad after the Bullet; because the Piece was mounted, he tried the strength of his Powder, and noted it down, to compare with other Powder, to know its strength by; and that is the way all Gunners must take, that intend to make good Shots at Random. Note also that all Gunners should be able to draw an exact Description of any Garrison, and every Object that lieth near his Works (by the Rules of the seventh Chapter of the Art of Surveying by the Sea-Compass in this 5th Book;) so that he may know what is within reach of his Guns, by which means he shall be ready at all times to know his Distances by his Maps: Then after he hath made one Shot, he may make another Shot to any Distance he pleaseth.

Example.

Example. Suppose I know the distance by my Map where the first Shot grazed to be 704 Paces, the mounture of the Piece being 4 degrees, how much must I mount the Piece to convey her Shoot 900 Paces.

You must proportion these distances of Random, to those in the Table following: saying, if 704 Paces require 370 Paces, (as in the Table at 4 degrees of Random) what number will answer unto 900?

Work thus. $\frac{370 \times 900}{704} = 473$

Or thus. The Logarithm of the Shot made 704 is ———— 284757

The Log. of the Numb. in the Table against 4 deg. *viz.* is 370 ———— 256820

The Logarithm of 900 Paces Random is ———— 295424

The Sum is ———— 552244

267487

Gives the Logarithm of 473 Paces, which I look for in the Table of Randoms, but find no such number there, but the next less is 461, against 6 degrees, and the next greatest is 550 against 7 degrees, the difference between these two Numbers is 44, and 461 is 12 less than 473, and 12 is near one fourth part of 44, and therefore it shews that the Piece must be mounted at 6 deg. $\frac{1}{4}$ to reach the Distance of 900 Paces.

A Table of the proportion of dead Ranges.

Deg.	*Randoms.*
0	206
1	225
2	274
3	323
4	370
5	416
6	461
7	505
8	548
9	589
10	630

This is the Table of Randoms that was made out of the forenamed Saker of Eight Foot long, and loaded with three Pound of Powder, and every Gunner is advised, if possible, to get Powder to make one by his own experience, and always to keep some of the same Powder to try any other Powder he shall have occasion to use, for this is one of the material things belonging to a Gunner, without which he can never make a good Shot; for at the time of a Leagure he must expect often to change his Powder, and sometimes shall have 9 Pound of one sort as good as 15 of another sort, as by shooting you may experience.

How to give Level to a Piece of Ordnance with the Gunners Rule at any Degree of Random.

Your Piece being Loaded in all Points, as is before taught, and you having brought the Piece in a Right-line with the Mark, the Dispert being placed upon the Muzzel-Ring; in like manner place your Ruler upon the Base-ring, holding it upright, which you try with a plum-line fixed thereto. Now having before the Distance to the Mark you intend to shoot at, admit it be 461 Paces, and the first shot you made for practice out of that Gun, conveyed her shot at two degrees of mounture 274 Paces, then according to the Tables of Random, I find 461 against 6 degrees, to which I must mount the Gun to reach the Mark.

Then to find by this Table how many Inches, and hundred parts of one Inch 6 degrees will require; look in the Table above and find on the left hand in the first Column the length of the Piece suppose 13 foot, under 6 degreee in the common-Angle, you shall find 16$\frac{44}{100}$ Inches, and to that height I set the Bead on the Lute-string; then cause the Piece to be mounted higher or lower, until you bring the Bead, the top of the Dispert, and the Mark all in one Line, stop the Piece in that position with a Coyn, then Prime, and give fire,

If you will shoot by the metal of the piece, subtract the height of the Dispert out of the Inches found by the Table, and the remainder mount your Piece unto; if the Dispert be 3 inches $\frac{1}{4}$ long, subtracted from 16 : 44 found in the Table, leaves 12 [illegible], or 12 [illegible] of an Inch, which is the height of the Bead to shoot the same distance by the muzzel-Ring without the Dispert.

How

How to divide the Gunner's Rule into Degrees by help of a Table, fitting it for any Piece from 5 Foot to 14 Foot long; and by the help of this Table, any Piece may be Elevated to any degree without a Quadrant, Ruler, or any other Instrument.

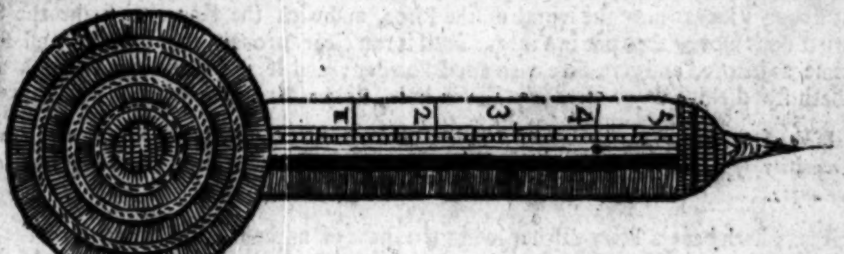
Note, this Table hath 11 Columns, the first shews the length of the Piece in Feet and half Feet, the other shews the Correspondent length from 1 degree to 10 degrees in Inches and 100 Parts. The Use of the Table.

If your Gun be 8 Foot long one Inch $\frac{68}{100}$ makes one degree; your Gun 12 Foot long five Inches $\frac{9}{10}$ makes 2 Degrees. Or you may set your Bead to 5$\frac{6}{100}$ Inch, to mount him 2 Degrees.

The len. of the Piece	1 *Deg.*		2 *Deg.*		3 *Deg.*		4 *Deg.*		5 *Deg.*		6 *Deg.*		7 *Deg.*		8 *Deg.*		9 *Deg.*		10 *Deg.*	
Feet and ½ Feet.	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100	*Inc.*	100
5 Foot long.	1	3	2	6	3	8	4	11	5	14	6	19	7	19	3	82	9	25	10	28
5 Foot and half.	1	14	2	28	3	42	4	56	5	70	6	84	7	98	9	12	10	26	11	40
6 Foot long.	1	22	2	44	3	66	4	88	6	10	7	38	8	58	9	78	11	8	12	29
6 Foot and half.	1	46	2	72	4	8	5	44	6	80	8	17	9	53	10	89	12	25	13	68
7 Foot long.	1	32	2	94	4	41	5	88	7	35	8	82	10	30	11	77	13	24	14	78
7 Foot and half.	5	58	3	14	4	71	6	28	7	85	9	42	10	99	12	55	14	14	15	71
8 Foot long.	1	68	3	36	5	4	6	72	8	40	10	8	11	76	13	44	15	12	16	82
8 Foot and half.	1	79	3	58	5	37	7	16	8	95	10	74	12	53	14	32	16	12	17	92
9 Foot long.	1	89	3	79	5	38	7	58	9	47	11	37	13	27	15	18	17	8	18	98
9 Foot and half.	2	00	4	0	5	0	8	0	10	0	11	10	14	2	16	3	18	4	20	4
10 Foot long.	2	10	4	20	5	30	8	40	10	30	12	61	14	73	16	84	18	56	21	8
10 Foot and half.	2	21	4	41	6	69	8	88	11	81	12	38	15	48	17	68	19	89	22	10
11 Foot long.	2	31	4	62	6	93	9	24	11	56	13	88	16	22	18	51	20	82	23	14
11 Foot and half.	2	42	4	48	7	26	9	68	12	10	14	53	16	95	19	37	21	80	24	21
12 Foot long.	2	53	5	6	7	59	10	12	12	65	15	18	17	71	20	25	22	78	25	33
12 Foot and half.	2	63	5	20	7	89	10	52	13	15	15	78	18	41	21	4	23	67	26	33
13 Foot long.	2	74	5	48	8	82	10	96	13	70	16	44	19	48	21	92	24	68	27	40
13 Foot and half.	2	84	5	68	8	52	11	36	14	20	17	4	19	88	22	72	25	56	28	42
14 Foot long.	2	95	5	90	8	85	11	80	14	75	17	70	20	65	23	60	26	56	29	53

How to make the Gunner's Rule, being an Instrument which will elevate a Piece of Ordnance, with more facility than the Gunner's Quadrant.

Because the Quadrant on the back-side of the Scale cannot be conveniently used at all times, especially when being near the Enemies Guns, and the wind blows hard, the Plumb-Line is too long before he stands still; to remedy this, the Gunner's Rule was invented; the Figure thereof you may see here; this Ruler must be 10, 12, or 14 Inches long or more, according as the Gun will require it, and must have a long slit down the middle thereof, the Head thereof make Circular according to your Gun, as you see in the Figure; the Instrument is described standing upon his Britch of a Piece of Ordnance; in the middle of the small narrow slit you must place a Lute-string, or a well twisted Silk-string with a Bead on it; this Bead must be set to Inches and Parts, as you find is agreeable to such a degree as you must mount your Gun to, on one side the slit there being placed a Division of Inches, and every Inch into 10 parts, and thus it will serve for all sorts of Guns; but if it be for a particular Gun, then on the other side you may place the degrees and minutes when you shall find it by the length of your Gun, how many Inches and Parts correspond thereto; but to use it with all sorts of Ordnance, let it only be divided into Inches and Parts.



How by the Table to Level a Piece of Ordnance, without the Gunners Rule.

If you have not a Quadrant, nor a Rule, and would make a shot at 4 degrees of Elevation, look in the Table, and find the length of the Piece, which suppose to be 9 foot and half, right against 9½ in the Angle under 4 degrees, you shall have 7 Inches to be the length of any Stick, cut and set it upon the Base-Ring, and bring the top of the said Stick, the top of the Dispert, and the Mark in a Right-line with your Eye, and Prime, and give Fire, and you may make a good Shot; and if you will have no Dispert, take the Dispert, and measure it upon the foresaid Stick at the Base-Ring, and from it cut off its length, and the Remainder you may use upon the Base-Ring, and it shall mount the Gun to 4 degrees as before; and bring the top of the Stick, the Muzzle-Ring, and the Mark in a Right-line, and you may make a goot shot; if the Dispert were 3 inches, that cut from 7 inches, the Remain is 4 inches for the length of the Stick to be set on the Base-Ring, for to level the Piece without a Dispert.

How to make a Shot at the Enemies Lights in a dark Night.

Upon such occasion, to shoot at a Light seen in the Night, Dispert your piece with a lighted Wax Candle, or with a lighted piece of Match, that with your Eye you may bring the Base-ring, the fired Match on the muzzel-Ring, and the Enemies Light in a Right-line (or mark) then give fire, and you may make a good shot.

How to make a perfect Shot at a Company of Horsemen, or Footmen passing by the place where Ordnance doth lie upon a Level-ground; and also to make a good Shot at a Ship Sailing upon a River.

Take a Piece that will reach the way or Mark in a Right-line that the Horse or Foot are to pass by, then your Gun loaded so with Powder that it may presently take fire, and taking a Tree, Bush, or Hillock, or some cross way for his Mark, and when the Enemy come near to that way in a Right-Line with his Gun, give fire: And shooting at a Ship in a River, he must put his Piece to some evident Mark on the other side the River, and when the Head of the Ship shall begin to be betwixt the Piece and the Mark, and then give fire.

How to cause the same quantity both of Powder and Shot, discharged out of the same Piece, to carry close, or more scattering.

In the Book of Mr. *John Bate* of *Extravagants*, he saith, take the quantity of a Pea of Opium, and charge it among the Case-shot, and it will make the said shot flie closer together than otherwise it would; for Opium is of congealing and fixative nature; this a Seaman found by experience.

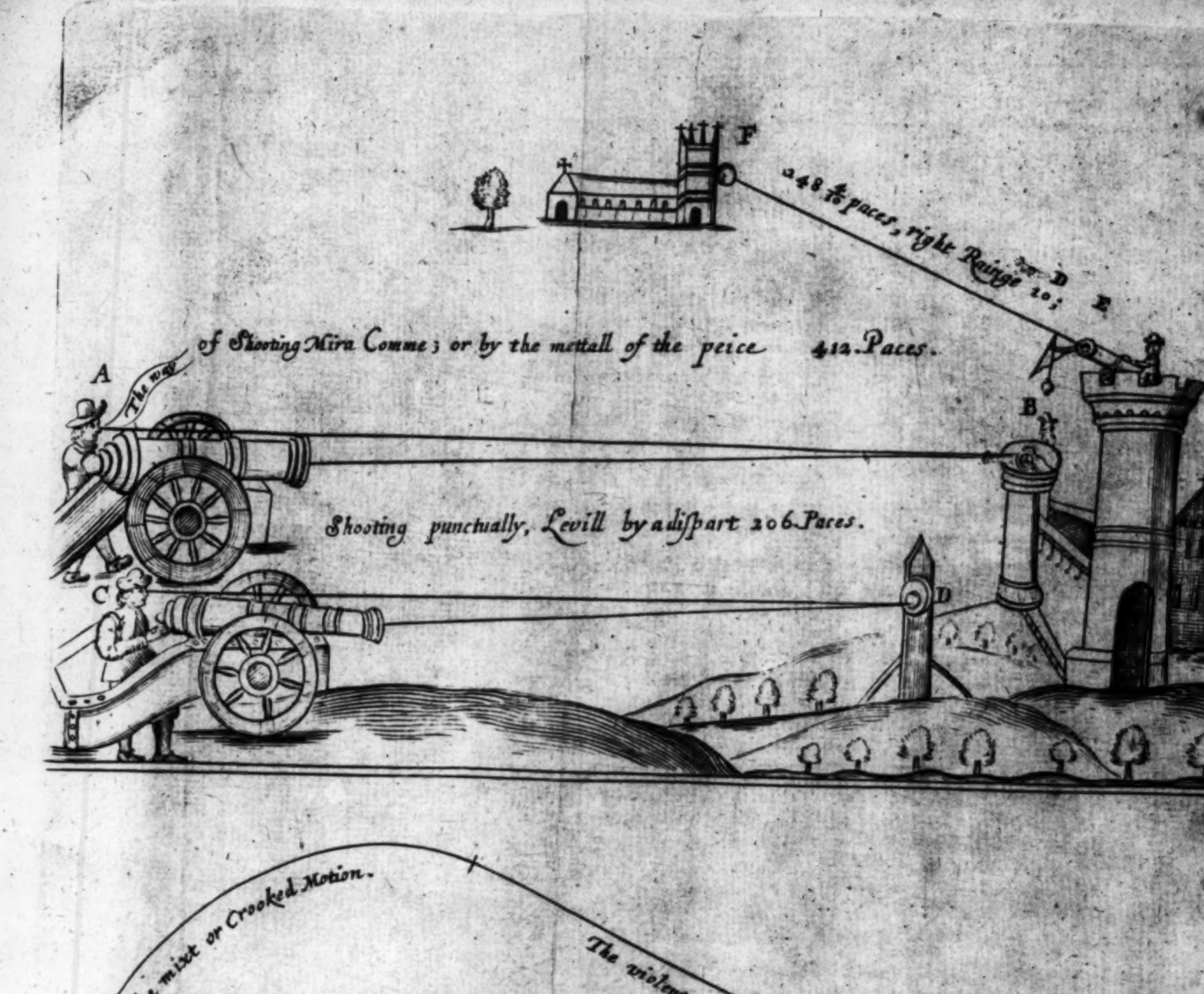
How a Shot which sticketh fast within the Concavity of a Piece, that it cannot be driven home unto the Powder, may be shot out without hurt to the Gunner, or to the Piece.

When any Piece of Ordnance is charged with such a shot that will not be driven home unto the Powder, then the Gunner to save his Piece from breaking, must so imbase the mouth thereof, that fair water for two or three days being put into the Touch-hole at several times, may run into a Vessel set under the mouth of the Gun, to save all the Saltpeter that was in the Powder: And then let the Gunner clear the Touch-hole, and put in as much Powder as possibly he can, and Prime, and give fire, and it will serve to drive out the shot.

But when a Shot hath lain long in a Piece, until it is grown rusty, and so sticks fast, put strong Vinegar into the mouth of the Piece, and with the Rammer strike the Shot until it doth move, then put in Vinegar until it run clear through the Powder and Shot, Prime as before, and give Fire with good Powder; and if it do not run through after it hath stood three days, clear the Touch-hole, Prime, and give fire.

A Piece of Ordnance at the same Elevation, and towards the self-same place, with the like quantity of Powder and Shot, discharged several times, what difference there is in their Ranges.

There hath been a Piece discharged in the space of an hour seven times, with the like quantity of Powder, Shot, and Mounture, and their Ranges have been found as followeth; the first Shot was conveyed 418 Paces, the second 438, the third 442, the fourth



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434, the fifth 427, the sixth 412, the seventh 395, so that the greatest difference from the first Shot was 24 Paces; this every Gunner must take notice of, if he intends to shoot well at Random; the reason of these things is this, the first Shot of Powder found the Chamber of the Gun moist, and the Air quiet, the second Shot, the Chamber was dried, and the Gun in a good temper, and the Air moved towards the Mark with the first Bullet, and having less resistance than the first, went beyond, and made the best Shot; and every Shot after come shorter and shorter, as the Gun grows hotter and hotter; the reason is, by how much hotter the Piece is, by so much the more attractive is the cavity of the Piece made; and becaúse the Shot is driven forth or expelled with no other thing, than by the Airs exaltation, or Wind, caused by the Salt-peter, therefore the oftner the Piece is fired, and the more hot, the more attractive she is, which sucketh and retaineth continually more of that Wind, which should serve to expel the Bullet; and therefore the virtue expulsive in that Piece, doth more and more decrease, and the Shot flyeth not with that swiftness as it did before in the two first Shots, which dried and brought the Gun into his best temper; but the third and fourth Shot is but little difference from the first, but the rest differ every Shot.

Nicolas Tartaglia doth report, that many Shots being made at a Battery by a Piece, it chanced by some occasion, the Piece rose up in such sort, that it touched the ground with its Muzzle, a little Dog running by, did smell into the Mouth of the Piece, and after a little time was drawn almost to the further end of the concavity: They pulled him out almost dead; this was done by the attraction of the Piece.

How to Weigh Ships sunk, or Ordnance under Water: Or to know what empty Cask will carry any sort of Ordnance over a River.

Nicolas Tartaglia hath well collected from the Learned *Archimedes*, and hath calculated the Proportion of Stone, and other Metals, what they will weigh in the Water, and in the Air.

All Men know by reason, that whatsoever is heavier than so much Water, as the Body of the Metal thrusteth out of the place, or Vessel, will sink; and being lighter than so much Water, will swim.

Tartaglia saith, that ordinary Free Stone weighing 93 pound in the Air, will weigh but 48 in the Water, which is near as 2 is to 1, between the Free Stone and the Water. And that Marble Stone that weiged 7 *l.* in the Air, will weigh but 5 *l.* in the Water, which is near as 7 to 2, between the Marble and the Water.

And Iron and Tin, that in the Air weighed 19 *l.* will weigh 16 *l.* in the Water; so it is as 19 to 3.

Brass weighing in the Air 65 *l.* will in the Water weigh 55 *l.* and so Brass is to Water as 65 to 55.

And Lead weighing in the Air 30 *l.* will weigh in the Water but 27 *l.* so Lead is to Water as 30 to 27.

And lastly, Gold in the Air being 17 *l.* in the Water it will weigh but 16 *l* so Gold is to Water, as 17 to 1. He also layeth down Rules to raise Ships, or Guns, or any thing else in the Water, that hath not lain too long, and docked it self in Ouze: For if the thing sunk be upon Sands or Rocks, it will weigh the better. He describes Vessels loaden, to be brought to the place where the thing sunk, and a Globe of Glass put in a Frame of Wood, and a place in the bottom of the Glass to put in ones head into the concave, he may both see and breath, and by a Windless Rope, and weight to sink it, he may first let down the weight, and after heave himself down in that Frame, (it is in the form of an Hour-glass) to the bottom, and so fling the Ship, and Guns, and when he will come up to the top again, unwind the Rope, and the Frame will be guided upright, and he and it will come to the top of the Water very safe, and fasten this Rope brought from the Ships to loaden Vessels, and then unload to the Vessels, and they will buoy up the Ship sunk, or any other thing from the ground.

Bristol, Sept. 12. 1667. *by experience of a Spanish Ship called the* Victory *of* Majork, *sunk in* Kingrode *at the* Pill; *her Burthen about* 300 *Tuns; we weighed her with* 4 *empty Lighters, of* 30 *Tuns a piece, by lashing the Lighters at low Water, Head and Stern; and at High-Water we heav'd the Ship on shore by a Grapple, the Ship did rise as the Water did flow; and the Low-Water or two afterward, the Ship was free, and swam; the Ship and Water was estimated to weigh* 1000 *Tuns, that the four Lighters weighed; she had no Goods in, but turned over as she was upon the Carein.*

Or

Or it may be done thus by a Float-Stage, and Capston, with a Trunk of Leather made so thick that no Water can come in, and with a pair of Glass Eyes fastened that no Water can go through, fitted to the Case of Leather within, and two Bladders blown at the brim or top of the Water, made fast to the Pipe of Leather to buoy the Mouth of the Pipe, while the Man goes down with Ropes fit to sling, and make them fast at liberty; then hale him up after a fit time, and by your Vessels, as before, and Float-Stage, heave and buoy up the thing sunk.

The weighing of Ships is where the Water ebbs and flows much.

Know this, that five Tun of Cask will swim a Canon of 8 or 9000 weight, 4 Tun a Demi-Canon, 3 Tun a Culverin, and 2 Tun a Saker, with all things belonging thereunto, as Planks and Ropes.

How many Horses, Oxen, or Men will serve to draw a Piece of Ordnance.

For every hundred weight of Metal, one Man; so a Piece of 8000 pound weight requires 80 Men, and as many more Men as the Carriage may weigh; for every 500 weight of Metal, one Horse, then 16 Horses will draw a Gun of 8000 weight; but in the Winter 24; also 17 Yoke of Oxen is thought sufficient to draw a Piece of 8000 weight, but in the Winter they had need to be one third part more.

Artificial FIRE-WORKS.

CHAP. XII.

A Description of the Mortar-Piece, and how to make one of Wood, and Past-board (for need.) Brass and Iron ones being wanting.

THe same Metal that makes the best sort of Brass Ordnance, they make Mortar-Pieces with, and by these Measures; if the Diameter or Bore be 9 Inches, let the Mortar be one Foot and a half in length, and let the Chamber, in which you load your Powder, be three Inches Diameter, and four and a half deep; the thickest of the Metal above the Touch-hole three Inches, and the upper part thereof an Inch and a half.

To make the Mortar-Piece of Wood and Past-board.

Provide a Wooden-Rouler of such bigness as you desire to make the Diameter of the Mortar, then grease your Rouler well, that the stuff may slip off that is put about it, which is Past-board and Canvas, and very well plied with hot Glue; and after let it dry a little while on the Rouler, and another while off from the Rouler; and when this kind of Trunk is very dry, put it on the Rouler, and set it in a Lathe, and cut off both ends of the Trunk with a Chizel very even, then turn a Foot thereto with a shoulder to put the Trunk upon, and in the middle thereof make the Chamber for your Powder; if the Piece be 8 Inches in the Mouth, let the thickness of the Past-board Trunk be 2 Inches thick, and 18 Inches long, the Britch or Foot 10, the Shoulder 2 Inches long, and 2 high, that when the Trunk is put on this Shoulder, and joyned with the Wood, it may be just even with the same; the Bore into which you put your Powder, must be two Inches high, and three deep, Plated with Copper, Lattin, (if it be possible) as also all the rest of the Wood that goeth into the Trunk; when you have put the Trunk into the Britch of the Wood, nail it round about the Shoulder, making holes for the Nails, and then driving in the Nails upon that Wood, that you made to receive the Past-boards or Trunk; then cover both Wood and Trunk with good Belch-Cord and Glue again, and let it be well dried, it will last a long time; and with such you may shoot Ballouns into the Air for Recreation.

How to fit and prepare Granadoes for the Mortar-Piece.

The Shot of Great Mortar-Pieces are most commonly one tenth part lower than the Bore, because of Cording them, to fling into the Mouth of the Piece; and for fear of secret Cracks, which cannot be easily espied, they are coated with Pitch, so that being fitted and prepared, they do but just fit the Bore.

How to make Fuses.

Every Granado Shell hath a hole left to put in a Fuse, or piece of wood just like a Faucet, this hole must be just one quarter of the Diameter of the wooden Fuse, which Fuse must

must be in length three quarters of the height of the Granado; make it taper, and then fill it with Composition, and drive it gently into the Powder that is in the Shell, leaving a little of it without: The Composition of this Fuse is made thus; take one pound of Powder, four ounces of Salt-peter, and one of Brimstone, first beaten to Powder, and sifted in a Sieve severally, these Ingredients being mixt together, your Composition is fit for use.

How to make Granadoes of Canvas for the Mortar.

The operation of these Granadoes made of Canvas is quite contrary to these already set down: These are only fit to fire a Town, they are not of so violent execution as the precedent, yet altogether as costly in the making; for the making of them, fit a Piece of Canvas upon a round Ball of Wood or Form, so big as you would have your Granado, then take this Composion following; four pound of Salt-peter, two pound of Gun-powder dust, and two pound of Brimstone; all these incorporated, and moistened with Oil of Salt-peter; fill your Case with this Compound, and cover it with Cords, and pierce the Sack full of holes, and in every hole put an Iron Barrel, charged like a Pistol; these must be driven into the Sack unto the head, then let there be a hole about an Inch deep, which shall serve to prime it with Powder-dust, moistened with Oyl of Petrol; be sure your Barrels have great Touch-holes, that the Rust through time may not choak them, and they will be ready for service many years.

How Granadoes are to be charged in a Mortar, and fired.

You must take great care in the loading or charging the Mortar, thus; first, weigh the Powder to a Drachm that you put into the Chamber, and after it put a good close Wad of Hay, or a Tampion of Wood, then cut a Turf off the ground that may just fill the bottom of the hole or bore of the Mortar next the Wad; your Granado being prepared, with a coat of Pitch and Cord, as before taught, fling it into the Mouth of the Mortar; observe to have the Fuse of the Granado in the middle of the bore, then go to the Britch, thrust up a Wire in the Touch-hole to make sure, then prime with the best dry Powder you have; for this is a ticklish sort of shooting; without care, your Life, and Mortar-Piece is now at stake; but we will give you very sure Directions how to give Fire.

Provide small Fuses, such as we taught you to make before for Shells, but less, about a quarter of an Inch bore, three quarters of an Inch thickness, and eight Inches long, fill these with good Powder-dust, moisten it with Oyl of Peter but a little, and put it in with an Iron Rammer, try whether you like the time they continue burning; if too slow, abate Oyl of Peter; if too fast, add more to it.

Thus being prepared, the use is, (*viz.*) thrust the Pick of your Linstock in at one end of the Fuse you mean to give Fire withal, bid one of your Assistants come to one side of the Mouth of the Piece, and give Fire to your Fuse, wherewith Fire the Fuse in the Mortar, and then with great speed give Fire to the Touch-hole; these Fuses are very certain to give Fire; but Match doth oft-times fail.

How to make Hand-Granadoes.

There is good use made of Hand-Granadoes in Assaults, and Boarding of Ships, and there be two sorts of them made; the first is shewed already, the second is made by Sea-Gunners upon a Mould made with Twine, and covered over with Cartrage-Paper, and Musquet Bullets cut in two, put with Paste and bits of Paper thick on the out-side; after you have doubled the Shells, Paste on some at a time, and let it dry, and then some more until it is quite full; then dip it in scalding Rozin or Pitch, and hang it up, and it is for your use; but you must have the innermost end of the Twine left out at the small hole for the Fuse; and before you Pitch it, you are to wind it out, and stop the hole, and then Pitch it.

The Shells are made of Glass, or neal'd Clay, or Paper.

To load them, fill these small Shells with Gun-Powder, then make a Fuse of one pound of Gun-Powder, six ounces of Salt-peter, and one of Charcoal; or if you will have them of less durance, you may take the Composition made for the Fuses, before spoken of for great Granadoes, knock the Fuse up to the head within one quarter of an Inch, which is only to find it by in the night; stop well the rest of the holes, if any Chinks are open, with soft Wax; then your first Shells must be coated with Pitch and Hurds, lest it should break with the fall; and be sure when you have Fired the Fuse, suddenly to cast it out of your hand, and it will do good execution.

How to make Fiery Arrows or Darts like Death Arrow-Heads.

Make your Head of Iron sharp and bearded, to stick fast, and to it have an Arrow or long shaft of Wood, and about the middle of that Head make fast a Linnen Bag in form of an Egg, leaving open at the end a hole, that it may be filled with the Composition following; take one pound of Peter, half a pound of Gun-powder, and as much Brimstone in Powder; all these Ingredients being mixt well, and mingled with Oyl of Petriol; with this fill the Bag round about the Arrow-head, then let all be bound about with Wire; and for Priming of these, dip Cotton week into Gun-powder wet with Water; and well dried again before it is used, and let the Arrows or Shafts be so put into the Head, that when they be stuck in a House or Ship-side, or any where else, the Man which endeavours to pull them out may be deceived, and pull only the Shaft, and leave the Head to burn the House, or Ship, or Mens Cloaths, or any thing else; if you throw or shoot it well, it will fire whatsoever Combustible Stuff or Matter shall be near it, as Sails, Timber, Pitch, Tarred places; and this will much annoy Enemies in storming a Work, or boarding a Ship.

How to make Fire-Pots of Clay.

Fire-Pots, and Balls to throw out of Mens Hands, or with a Bascula, may be made of Potters-Clay, with Ears, to it hang lighted Matches, and throwing them, if it lighteth on a hard thing, it breaks, and the Matches fire the Powder, and the half Bullets of Musquets contrived upon them as before, disperses, and doth much mischief; their mixture is of Powder, Peter, Sulphur, and Sal-armoniack of each one pound, and four ounces of Camphire pounded, and searced, and mixed well together with hot Pitch, Linseed-Oyl, or Oyl of Peter; prove it first by burning it, if it be too slow, add more Powder, and if it be too quick, more Oyl, or Rozin, and then it is for your use.

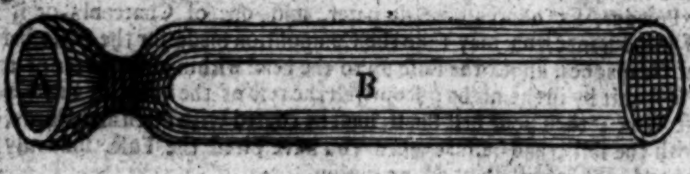
How to make Powder-Chests.

You must make them with 2 Boards, to be nailed together, like the ridge of a House, and one longer and broader to the bottom thereof; between the three Boards put a Cartrage, then make it up like a Sea-Chest, and fill it with Pibble-stones, Nails, Stubs of old Iron; then nail the Cover on, and the end to the Decks in such a place as you may fire the Powder underneath through a hole made to put a Pistol in.

How to make Artificial Fire-Works for Recreation.

We shall not describe the Moulds in particular, but refer you to *Babington*, *Bate*, *Malthus*, or *Norton*'s Fire-Works; but we will lay down such Rules, as shall be as soon conceived without Figures, only a Rouler or Mould for to make the Paper upon, and that may serve for all the rest, they being made in the same manner.

To make good experienced Rockets our way, do thus; get a Form or Rouler to be turned in a Lathe, what thickness you please, and intend to make your Rockets, and let his length be eight times the Diameter; if it be ¾ of an Inch in thickness, the length will be 6 Inches, put so many Rolls of Paper on this Form, until it is half an Inch thicker; or make it ¼ Inch the whole, then paste the upper side to the rest; then you must contract the Paper together an Inch from the Mouth, thus; dip an Inch of the Case in Water, the Formor in him, and with Twine about ½ of an Inch from the end gather it in; but let a Formor, or a thing near the bigness be put into his Mouth, while you draw it in with the Twine and choak it; you must remember to leave a small hole to put in a Wire through the Composition half way the Rocket, as big as a Bodkin; then take out the Formor, and dry them, and they are for use at any time, the Figure following makes all plain; A is the Mouth of the Rocket, B so far the Bodkin must be thrust up the middle; you must be provided with a smaller Bodkin, which when your Rocket is filled with the Composition, and tied to the Rod, you must thrust this Wire Bodkin in at the Mouth, strait up to the midst of the Rocket, having a care not to thrust it more upon one side than the other.



To

To make the Composition for Rockets of any size.

The Reader may make use of these Rules, not upon trust out of Authors, but found by Practice and Experience; and first for Rockets of one ounce; you must use only Canon-powder dust, being beaten in a Mortar, and finely searsed; this makes him rise very swift, making a great noise, but carries no Tail. These of more Opperations are made by putting one ounce of Charcole-dust to eight ounces of Powder; this Composition will hold for Rockets, one, two, and three ounces; but for these of four, take three ounces of Charcole-dust to one pound of Canon-powder dust continuing that Rule, until you come to Rockets of ten ounces; and also for Rockets of a pound, take one pound of Powder-dust, and four ounces of Charcole-dust, and these are big enough for any Recreation or Delight.

To fill the Rockets with this Composition.

Hold the Mouth downwards where it was choaked, and with a Knife put in so much as you can of the Receipt provided for that size at one time, then with a Rammer fitted to the Case, and with a Mallet give three or four indifferent knocks, then put in more Composition until it be full, every time knocking the Rammer, as before, until the Composition come within one Diameter of the top; then put down a piece of Pasteboard, and knock it in hard, prick three or four little holes therein; then put fine Pistol-powder in almost to the top, and upon that another cap of Paper, upon which put a piece of Leather, that it may be tied on the top of the Rocket, and fast glued on; then get a strait Twig, and bind it upon the Rocket with good Twine; it must be no heavier, than being put upon your Finger an Inch and a half from the Mouth of the same, that it may just balance the Rocket, then it is prepared for use.

To give fire to one or two Rockets. Set your Rockets Mouth upon the edge of any piece of Timber, that stands so high from the ground, that the Stick may stand perpendicular from it downwards, or upon a side of a Wall or Carriage-wheel, or any dry place whatsoever; then lay a train of Powder that may come under the Mouth thereof; give fire thereto, and you have done; but to fire more Rockets than one, that as one descendeth, the other may asend by degrees: Make this Composition following; of Roch-Peter 8 ounces, Quick-Brimstone four ounces, and fine Powder-dust two ounces, which lay in a line, from one Rocket to another, they being placed ten Inches, or a Foot one from another: give fire to this Composition, and you have your desire, if you did prick the Rocket with the Wire, as directed; you shall see how gallant one will mount the Air, when the other is spent.

To make flying Serpents and Rockets that will run upon a Line, and return again.

For this you must provide a small Rowling-Pin about one quarter of an Inch in thickness; upon which roul seven or eight thickness of Paper; fill them four Inches with Powder-dust, sometimes putting between the filling a little of the Composition for Rockets of ten Ounces, and at the end of four Inches choak him; fill two Inches more with Pistol-Powder, then choak the end up, and at the other end put in a little of the mixture for Stars, which follows, and choak between them and the Composition, and it is fit for use; but divers of those with the Starry end downwards upon the head of a Rocket and Powder-train to blow them out, when the Rocket is spent, they will first appear like so many Stars; when the Stars are spent, taking hold of the Powder-dust, they will run rigling to and fro like Serpents, and when that Composition is spent, they will end with every one a report, which will give great content to the beholder.

I did omit to speak of Runners in its proper place, for that is the Composition, which you must make them of, very carefully, whether they be double or single, or those that carry Dragons, Men, or Ships, or other Shapes in motion, lest they shame their Master; the Line must therefore be fine, even, and strong, and being rubbed over with soft Sope to make it slippery, and not easily to take fire; Those that turn Wheels, may have a further addition of Roch-Peter in their Receipts to add pleasure and life to the beholders; You must have a piece of Cane as long as the Rocket, and bind to the Rockets, and so that ones Head may be to the others Vent, that when one hath carried the Cane on the Line to the end thereof, the other may fire, and bring him back again to the Tower or place where it was fired: these Figures are made with strong Paper or Parchment, and with Lattin, and Wire, and Twine, until they be brought into these Shapes, and then painted like Ships, or Dragons, or like the thing it carries with it.

How

How to make Fire-Wheels, or as some call them Girondles.

First be provided with Spinning-Wheels, or the like, made easie to run round upon its Axis, Horizontal, or Vertically; and put Flaggs on the top of the middle, to set out the wheel; bind Rockets to the wheel, and Crackers betwixt each Rocket, with the Mouth of one towards the Tail of the other; thus continued, until you have fitted the Wheel quite round; which done, cover them with Paper pasted over, and coloured handsomly to set it out, that one taking fire, they may not fire all, and daub Soap upon them quite round, leaving the mouth of one of them open, to give fire thereto, the first Rocket being burned will set fire to the rest one after another, keeping the Wheel in a continunal motion, until they be all spent; you may bind Fire-Lances to these Wheels, either upright, or near over athwart, which will make to appear diversity of Fire-Circles; you must take care to place your Wheels called Girondles at convenient distance from other Fire-Works, lest they should make a confusion, and spoil all the Work.

How to make divers Compositions for Stars.

For Stars of a blue colour mixed with red, the Composition is of Powder-mealed eight Ounces, Salt-Peter four, Quick Brimstone twelve Ounces, meal all these very fine, and mix them together with two Ounces of *Aqua Vita*, and half an Ounce of Oyl of Spike; which let it be very dry before you use it.

Another Composition which will make white and Beautiful Fire; take Powder eight, Salt Peter 24, quick Brimston two, Camphire one Ounce, meal these ingredients, and incorporate them; meal the Camphire with dipping your Pistle into a little Oyl of Almonds, and it will meal presently, and keep it close from the Air, or else it will become of no use.

Another White Fire which lasteth long; take Powder four, Salt-Peter sixteen, Brimstone eight, Camphire one, Oyl of Peter two Ounces, meal these that are to be mealed, and mix them according to the former derections.

How to make and use the Stars.

Take little square pieces of Brown Paper, which fill with either of the foresaid Compositions which you like best, fold it down, rowling it till you make it round, about the bigness of a Nut or bigger, according to the size of your Rocket that you intend them for, Prime them with drawing through them Cotton-Week, and they are prepared to make fast to the Wheels: You may also make them thus; you must have a Rowler which must be as big as an ordinary Arrow, which shall be to rowl a length of Paper about, and paste it round, and dry it well, fill it with a Thimble, and thrust it down with a Roler, and then cut it in short Pieces about half an Inch long; then you must have in readiness either hot Glue, or Size mingled with red Lead, dip therein one end of your short Pieces, lest they take fire at both ends together; besides, it will not so easily blow out; these being thus done, set them to dry until you use them; in the top of the Rocket, whereas before you were to fill it with Pistol-Powder; now you must put but a very little, and that is to blow the Stars out, which must stand in the room of the Powder, and on the top of that another Tire with strewing a little Powder and Dust; and in like manner another, to a third or fourth, putting a little small corned Powder between them, until you come unto the top of the Rocket-Case, there put a Paper over the Head of it, and tie it close about the top, that none of the Powder come from between the Stars; the Cotton-Week is such as the Chandlers use doubled six or seven times, dipped in Salt-Peter Water, or *Aqua Vita*, wherein some Camphire hath been dissolved; or for want of either, in fair Water, cut it in divers pieces, rowled in mealed Powder dried in the Sun, and it is done.

How to represent divers sorts of Figures in the Air with Rockets.

When you have divers Rockets to make for a great Fire-Work, let one be with a Report, another with Stars, another with Golden Hair or Rain, one with Silver Hair or Rain, which it seems to be when you are right under it; and upon the Head of another Rocket place the Serpents, and they will make most delightful Sport.

How to make Silver and Golden Rain, and how to use them.

You must provide store of Goose-Quills, which you must cut off so far as they are hollow; the Composition to fill them is, two Ounces of Coal-dust, and one Pound of Powder

Powder well mixed; having filled many of these Quills, you shall place them in the same place as I told you to put the Powder and Stars, putting a little Pistol-Powder to blow them out, as you did the Stars, and fill the top of the Case as full of them as you can, with the open end downwards; so soon as the Rocket is spent, there will appear a Golden Shower, or Rain; or with the Composition for White-Stars filled in the Quills, will make a Shower of Silver Rain.

How to make Fire-Lances.

Make them thus; first, you must make Cartrages, or Cases just like the Cases for Rockets, only those for a need may be made with Pastboard, and glued, as they are formed round, but the former is better; let them be filled with the dry Composition for Stars. Prime them with wet Gun-Powder, the lower end of the Case is stopped with a Piece of Wood, to the end they may be nailed and stirred when and where they shall be used, the Wood being about three Fingers breadth out of the Case or Cartrage, or as long as you will.

The manner how to make Balloons for the Mortar-Piece.

You must have a Former or Rouler twice the length of the Diameter, and of the bigness as you will have the inside of your Balloon, and upon the former put so many Pastboards as you shall think sufficient for strength, then paste or glue them well together, and choak him at the end with a string, leaving a small hole for a Port-fire, which must be made just like a Rocket, but no holes in it as the Rocket hath, and of such length as is fit: Now to fill the Balloons, place all your Serpents within it together with Stars, Rockets, and Crackers, leave very little room within the Case, or Cartrage; and being filled, put in as much Powder-dust as you can, that it may run every where through the Chinks between the Serpents, Rockets, and Stars, that they may all fire, and that the said Powder-dust may break the Balloon; these things thus done, choak up the other end close, and charge it in the Mortar, as we have taught you to do the Canvas-Granado; you may shoot it when you please, and you will make most excellent delight to the Spectators, and credit to your self.

A most precious Onguent for any Burning.

Divers men in the practice of Fire-Works one time or other chance to be burned, or blown in the Face by Powder; here you have Mr. *Malthus's* Salves, which was known by often Experience to be very good, and will fully cure you.

The SALVES.

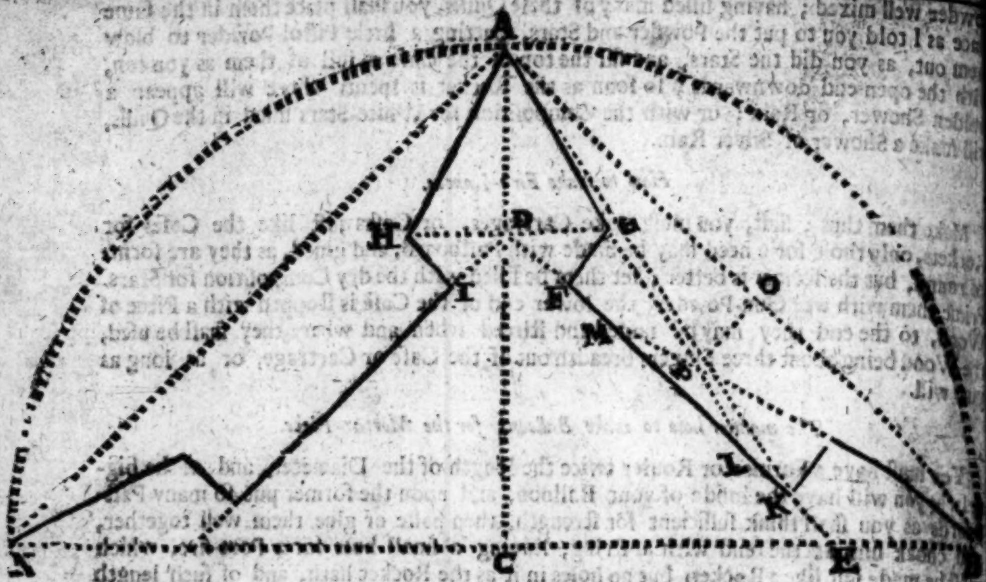
Take fresh Grease, or Lard, as much as you please, and boyl, and take off the Scum, until there arise no more Scum; then set the Lard three or four nights abroad, after which it must be Washed in running Water to take away the Saltish nature, and to make it White; then melt it for your use.

Or the White of an Egg, and fresh Butter being mingled together, and well beaten into an Oyntment, is excellent good.

Another most excellent. Take a Stone of Quick Lime, and let it be dissolved in clear Water, and when the water is settled, pour it out gently from the Lime through a Linnen cloth, then put as much Sallet-Oyl as you have Water together, and beat it all to an Oyl; you may keep it for such uses, and you have a most Soveraign Cure for all manner of Burnings.

A Compendium of Fortification.

First, I will describe part of a Tetragon or square Fort, and explain the Names of the Sides and Angles thereof, as in the Figure following.



Names of the Sides of a Fort.

A B the Outward side of the Polygon, and D E the Inward side.
C A the Semidiameter of the Outward Polygon, and C D the Inward.
I H A G F the Bulwark or Bastion.
A G, or A H, the Front or Face of the Bastion ——————— 280 Feet.
A D the Capital or Head Line.
D I, or D F, the Gorge Line.
I H, or F G the Flank, and F M the second Flank.
D G the Espaule, or Shoulder.
F K the Curtain ——————————————— 420 Feet.
A K the longest Line of Defence —————————— 720 Feet.
A L the shortest Line of Defence.

Names of the Angles.

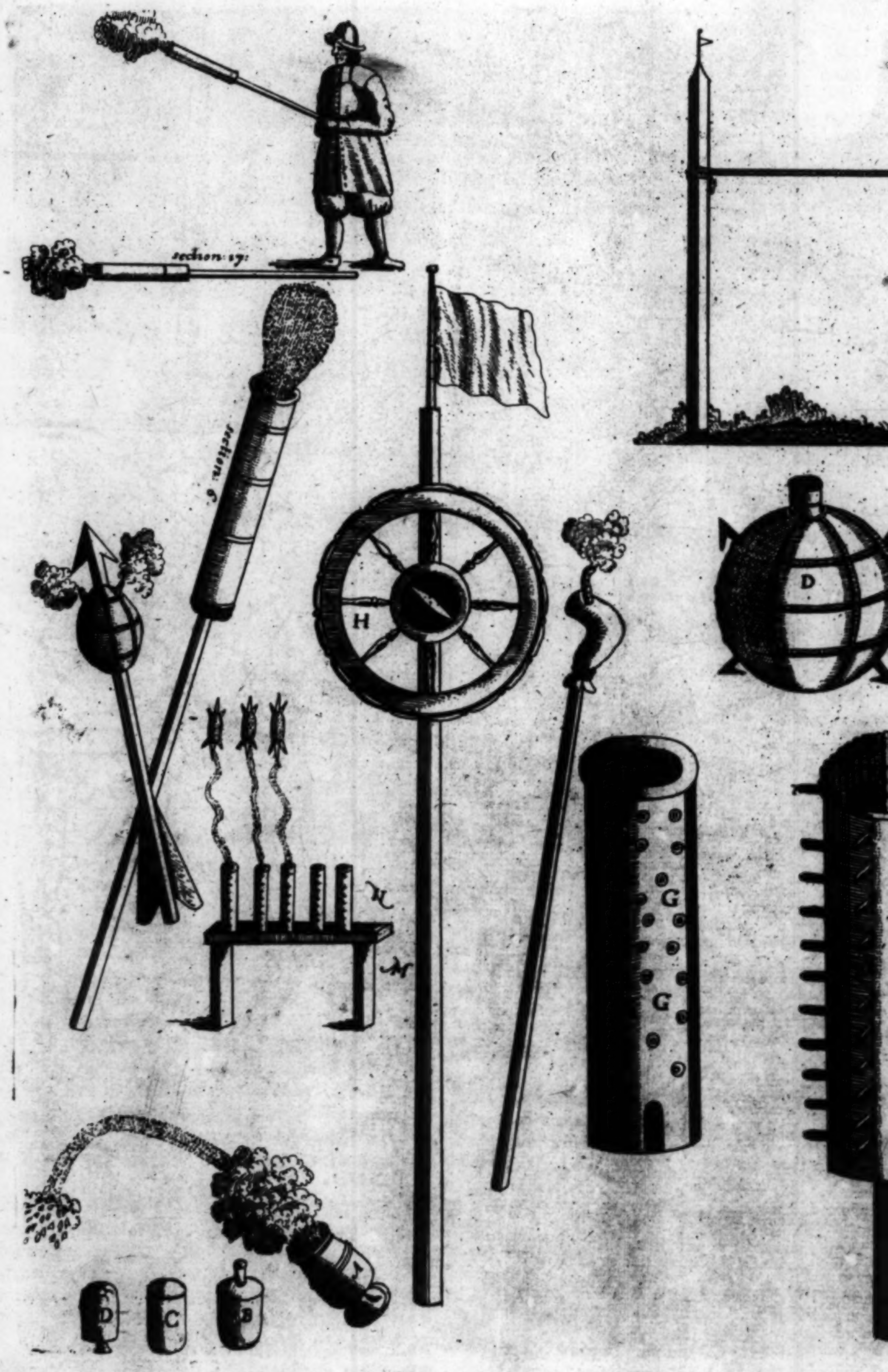
N A B the Angle of the Polygon, and N A C the half Angle.
H A G the Flanked Angle of the Bulwark.
A G F the Angle of the Shoulder.
F D G the Angle forming the Flank, commonly 40 Degrees.
G A O the inward Flanking Angle.
A P B the outward Flanking Angle, and A P O half the same.

Note, That the Bastion or Flanked Angle H A G must never be less than 60 Degrees, neither above 90 Degrees; but as near as you can to an Angle of 90 Degrees: So that it may be defended from the Flank and Curtain on either side.

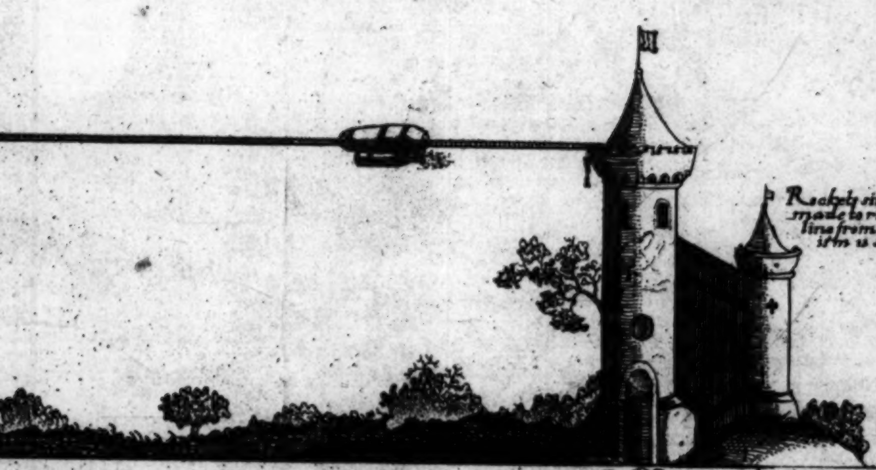
The longest Line of Defence A K not to be above 12 score Yards, that is, 720 Feet, being within Musket-shot, and the breadth of the Rampier to resist the Battery 100 Feet.

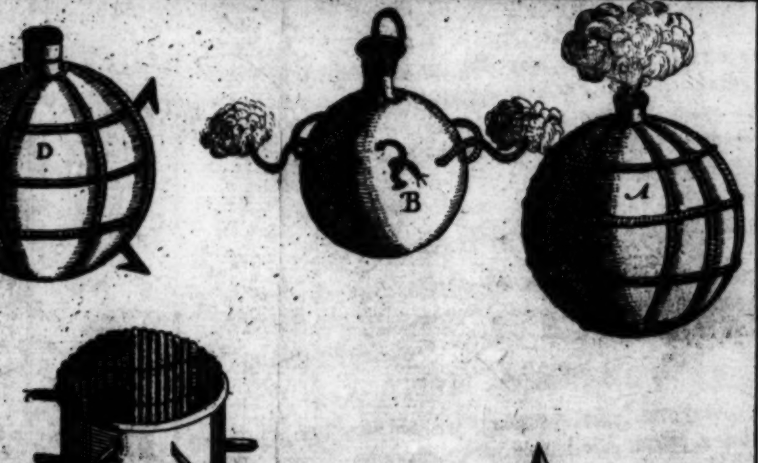
To describe a Fort of five Bulwarks, or any other; so that the Bastion, or Flanked Angle of 8 Bastions or Bulwarks exceed not 90 Degrees, by the Line of Chords.

First, draw an obscure Line, as A B; and upon A, as a Center, with the Chord of 60 deg. describe an Arch as C D E; and from C lay down half the Polygon Angle (which in the Table following the Figure you shall find to be) 54 deg. as C D; also the same again from D to E and draw the Line A E. Now divide the half Polygon Arches C D and D E each into three equal parts, as in F H I G, and from two of those parts from D, as F and G, draw Lines unto the Bastion Point at A. Then take any convenient distance and lay the same on these Lines from A unto K and L, which shall make the Front or Face of the Bulwark. Next, from the shoulder at K let fall a perpendicular to A B, as K M; and on the Center at K describe an Arch of 60 deg. from M toward N, and from M lay



section: 17:
section: 6
H
D
G
G
D
C
B





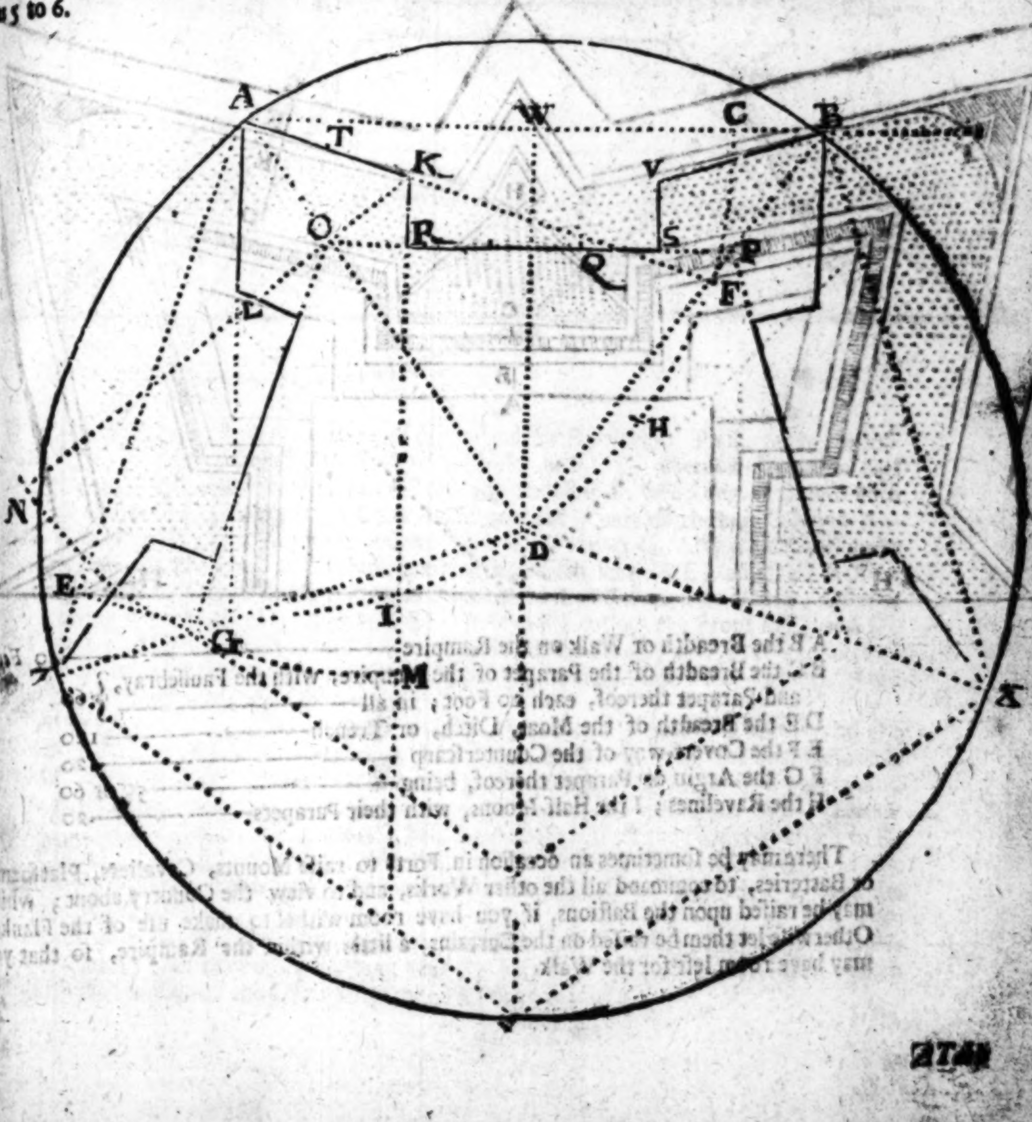
The Ball A is a Granado,
coated armed and lopdey
sect: 4.
Fire Potts of Clay wth eares
and markes is B
section. 7.
Balls to fire and stick is D
made of ye same stuffe: as
7 section
Fire Arrowes or darts sect:
ye 6 is E
FG is a sillinder Granado
of turned timber to
shoote fliers section
the 10.
Vertuall wheele is H sect:
12 by wch you may under-
stand ye form of horizon-
tall wheeles or any other
sort.
ABCD are the morter
Peice mould and Ballons
section 18.
And M N is ye wooden
Morters or Chambers as
in section 18

to lay down on the same Arch 50 deg. or more exact 49 deg. 24 min. and so draw K N; which will cut the Semidiameter of the Polygon in the Point O; so shall A O be the Capital Line of the Bastion. Then from O draw a Line parallel to A B, as O P; so shall you have O R for the Gorge Line, and R K the Flank. Now for the Curtain, take half the Front A K, as A T, and lay it down three times from R toward P, which will fall in S, so is R S the Curtain. Then on the Point at S erect a Perpendicular, S V, equal to R K, which shall be the Flank of another Bastion; and so the Front K A being laid from V, shall cut the first Line A B in B; so drawing V B, you have the Front of the same Bastion.

Lastly, Divide A B in the Middle, as in W and from W raise a Perpendicular to A B, which will cut the Semidiameter of the Polygon in the Point D; so is D the Center of the Polygon, And with the same Simidiameter D A you must describe a Circle, of the which A B is the $\frac{1}{7}$ part, which distance will reach from B unto X, and from X unto Y, and so to Z, and so to your first Point at A, where you begun your Work.

For the other Bastions, they may be easily transported from the first Bastion. And note, That if your Fort exceed 8 Bulwarks, you must add 15 deg. to half the Polygon Angle, so have you the Bastion Angle, and then work as before. But in the Forts that exceed not 8 Bulwarks, where the Bastion Angle will not be above 90 d. you must take the $\frac{2}{3}$ Part of the Angle of the Polygon.

The longest Line of Defence is from A unto Q, and should not exceed 720 Foot (because of being within Musket-shot) the Curtain R S about 420 Foot, and the Front A K 280 Foot: And for the Flank R K, and Gorge R O, their proportion commonly is as 6 to 7: But the Angle K O R forming the Flank is about 40 *gr.* by which the Proportion is near, as 5 to 6.



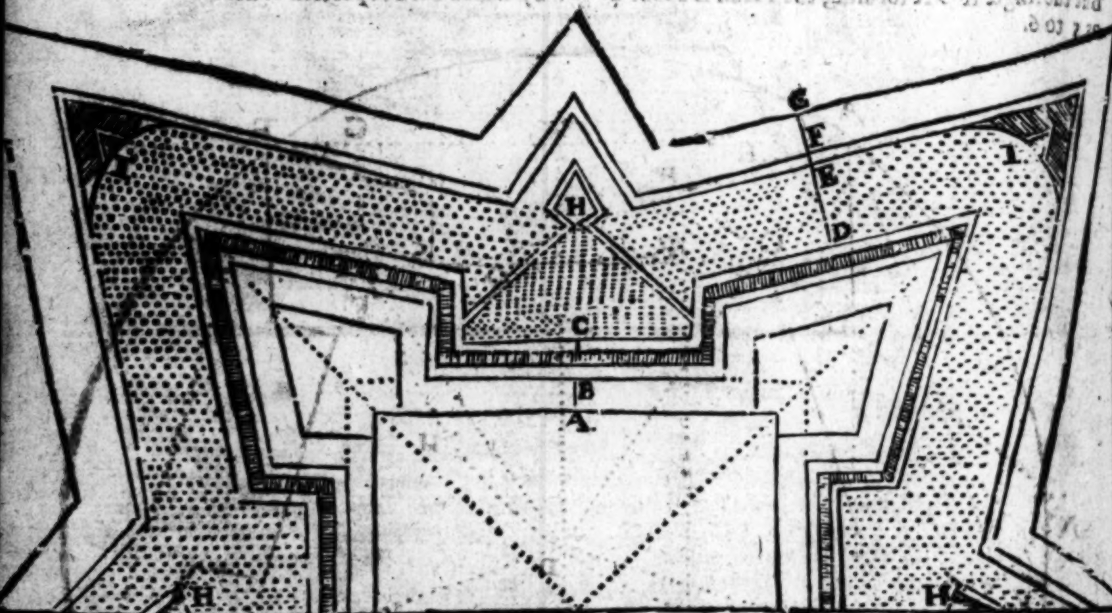
A Table for 8 Bastions.		
Polygons.	$\frac{1}{2}$ *Angle of the Polygons.*	$\frac{1}{2}$ *Angle of the Bastions.*
	Degrees.	*Degrees.*
4 Tetragon	45	30
5 Pentagon	54	36
6 Hexagon	60	40
7 Heptagon	$64\frac{2}{7}$	$42\frac{6}{7}$
8 Octagon	$67\frac{1}{2}$	45

The $\frac{1}{2}$ Baiston Angle is here found by taking the $\frac{2}{3}$ of the $\frac{1}{2}$ Polygon Angle: So the Bastion Angle will be an Angle of 90 deg. in the Octagon. And no more must the Bastion Angle be in any Polygon.

A Table of 12 Bastions.		
Polygons.	$\frac{1}{2}$ *Angle of the Polygon.*	$\frac{1}{2}$ *Angle of the Bastion.*
	Degrees.	*Degrees.*
4 Tetragon	45	30
5 Pentagon	54	$34\frac{1}{2}$
6 Hexagon	60	$37\frac{1}{2}$
7 Heptag.	$64\frac{2}{7}$	$39\frac{9}{14}$
8 Octagon	$67\frac{1}{2}$	$41\frac{1}{4}$
9 Enneag.	70	$42\frac{1}{2}$
10 Decagon	72	$43\frac{1}{2}$
11 Undecag.	$73\frac{7}{11}$	$44\frac{7}{22}$
12 Dodecag.	75	45

The $\frac{1}{2}$ Bastion Angle is here found by adding 15 *d.* to $\frac{1}{2}$ the Polygon Angle, and take the $\frac{1}{2}$ thereof: So the Bastion Angle will be an Angle of 90 Deg. in a Dodecagon.

Of the Works that are in or about Forts of most Importance.

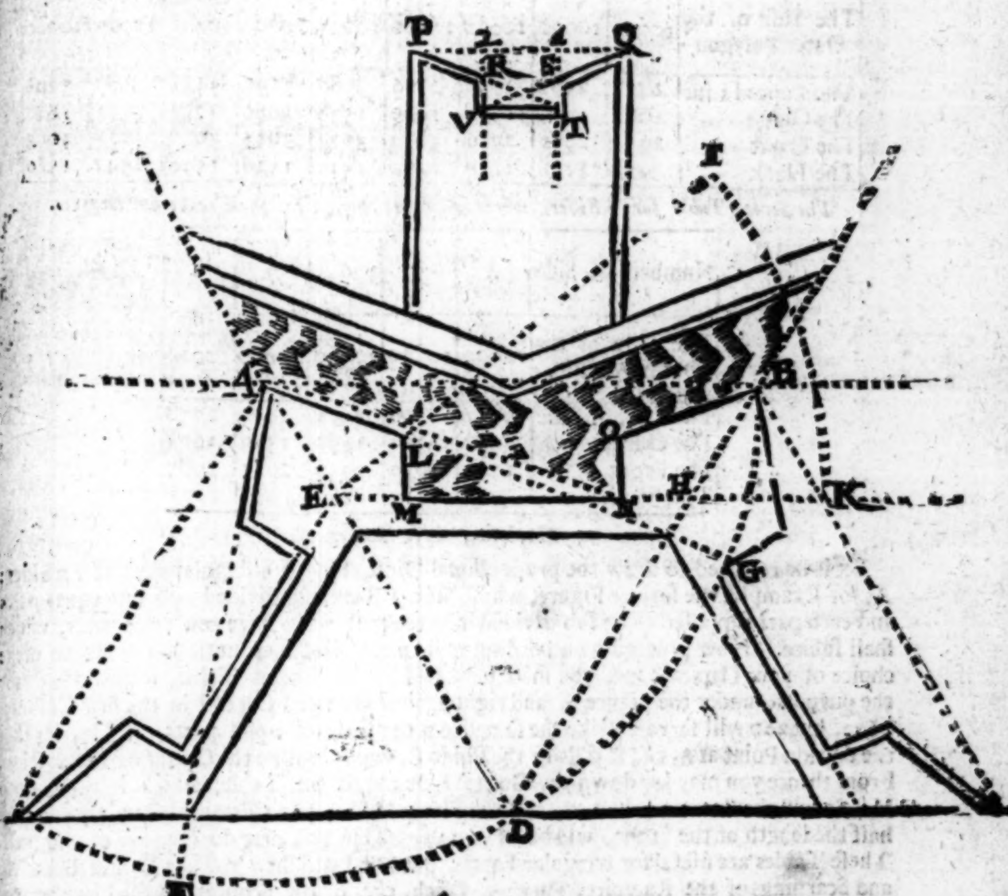


A B the Breadth or Walk on the Rampire —— 40 *Feet.*
B C the Breadth of the Parapet of the Rampire, with the Faussebray, and Parapet thereof, each 20 Foot; in all —— 60
D E the Breadth of the Moat, Ditch, or Trench —— 120
E F the Covert-way of the Counterscarp —— 20
F G the Argin or Parapet thereof, being —— 50 or 60
H the Ravelines; I the Half-Moons, with their Parapets —— 20

There may be sometimes an occasion in Forts to raise Mounts, Cavaliers, Platforms, or Batteries, to command all the other Works, and to view the Country about; which may be raised upon the Bastions, if you have room withal to make use of the Flanks: Otherwise let them be raised on the Curtains, a little within the Rampire, so that you may have room left for the Walk.

To

To draw the Platform of a Fort, beginning with the Capital (or Head) Line; and also to draw the Horn-Works.



LEt the Fort be an *Hexagon*, that is, of six Bastions or Bulwarks. First, draw the line A B, and upon A describe an Arch of a Circle, as B D C, whereon lay down half the Polygon-Angle, which in the former Table you shall find to be 60 deg. as from B unto D, and thence to C; and draw A C and A D, now the $\frac{1}{7}$ part of the half Polygon-Angle is B G and C F; then draw the obscure Line A F, and A G. Next you shall make choice of the Capital Line, of any sufficient length, which let be A E; and from E draw a Line parallel to A B, as E H, continued; and upon the Point E, as a Center, describe K I, making it an Angle of 40 deg. as K E I; so shall E I cut out the Front in L, as A L: So from L let fall the Perpendicular L M, which shall be Flank; and M N the Curtain shall be as formerly the whole length of the Front, and a half more. For the rest of the Work, you must proceed as formerly.

For the Horn-Works. You must continue the Flankers M L and N O unto P and Q; then take the longest Line of Defence A N, and lay it thereon from the Shoulders at L and O, unto P and Q; drawing the Line P Q: dividing it into three equal parts; and from those parts 1 and 2, draw Parallels unto P L and Q O: also from those Points P and Q draw Parallels to the Fronts A L and B O, those will cut the former Parallels in R, S, T, and V, which Intersections will limit the Fronts, Flanks, and Curtains, as you may easily perceive; unto which you must make the Rampire, Parapet, *&c.* as in the former Works.

Now follow two Tables; the one for 12 Bastions, and the other for Forts of 8 Bastions; whereby you may trace out any Fort by help of a Line of Equal Parts, which shall divide the Side of the Outer Polygon into 10000 parts.

The First Table for 12 Sides.

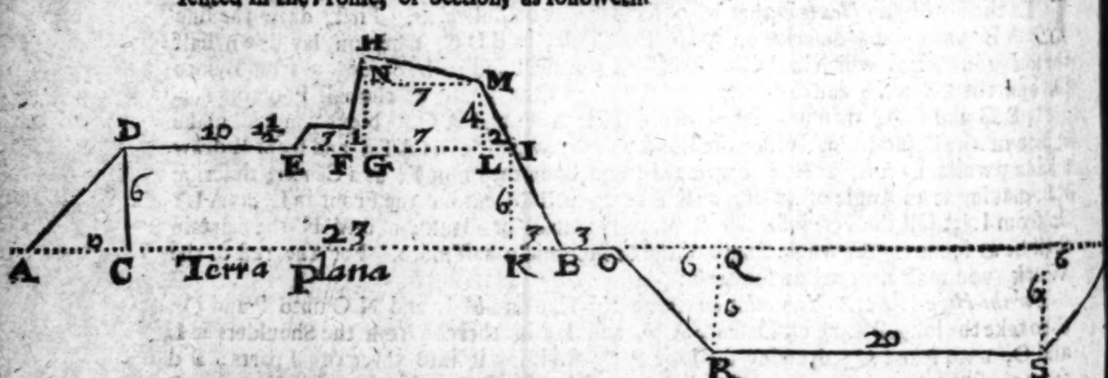
Number of Sides	4	5	6	7	8	9	10	11	12
The Side of the Outer Polygon	10000	10000	10000	10000	10000	10000	10000	10000	10000
The Capital Line	2428	2592	2756	2926	3086	3136	3148	3180	3204
The Gorge	1088	1264	1378	1470	1538	1640	1722	1792	1842
The Front	2914	2952	2986	3014	3024	3054	3070	3082	3094
The Flank	970	1128	1246	1360	1516	1526	1536	1542	1546

The Second Table for 8 Sides, whose Bastion Angle then shall make 90 Degrees.

Number of Side	4	5	6	7	8
The Side of the Outer Polygon	10000	10000	10000	10000	10000
The Capital Line	2396	2498	2602	2695	2778
The Gorge	1126	1327	1480	1599	1698
The Front	2914	2939	2959	2975	2987
The Flank	940	1113	1242	1342	1422

The Use of these Tables.

Let it be required to draw the proportional Dimension of a Regular Fort of six Sides: As for Example, the former Figure, whose Side A B must be divided into 100 equal parts and each part supposed to be sub-divided into ten parts: So have you 1000 parts, which shall suffice. Now proceeding according to former Directions, until you come to make choice of your Capital Line, you shall here find in the Second Table, which is best for the purpose, under the Figure 6, and right against the word Capital in the first Column, 2602, but 260 will serve: Take the same from the scale of equal parts, and lay it from the Bastion Point at A, and it falls in the Point E, which will be the Center of the Bastion. From thence you may lay down the Gorge Line out of the Table, which is 148, unto M: So will the Front A L be 296, and the Flank M L. The Curtain being once and a half the length of the Front, will be M N 444. Thus you may do for any of the rest. These Tables are useful for Irregular Forts; but first I will shew you the Height, Breadth, and Scarpings of the Rampire, Parapet, Ditch, *&c.* of the Sconces, as they are represented in the Profile, or Section, as followeth.

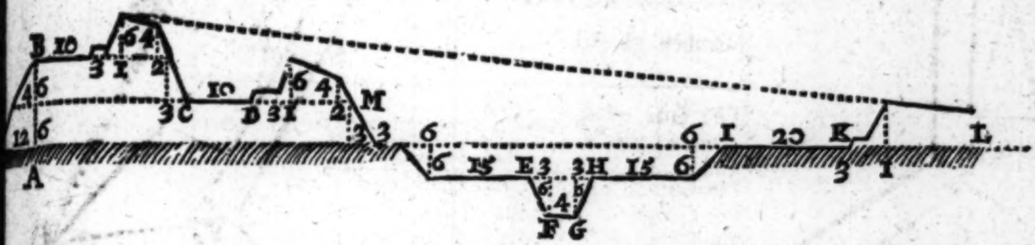


The Breadth of the Rampire may be 24, 30, or 40 Foot; but here A B is —— 32
The Inward Scarp A C —— 6
The Height of the Rampire C D —— 6
The Breadth of the Walk of the Rampire D E —— 10
The Breadth of the Bank or Foot-pace of the Parapet E F —— 3
and the Height of the same Foot-pace —— 1½
The Inward Scarp of the Parapet F G —— 1

The

The Inward Height of the Parapet G H	6
The Breadth of the Parapet at the Foot F I	10
The Outward Scarp of the Rampire B K	3
The Inward Scarp of the Parapet I L	2
The Outward Height of the Parapet L M	4
The Thickneſs of the Parapet at the top M N	7
The Brim of the Ditch B O	3
The Breadth of the Ditch at the Top O P	32
The Scarp of the Ditch O Q	6
The Depth of the Ditch Q R	6
The Breadth of the Ditch at the bottom R S	20

The Profile or Section of a Fort with a Fauſſe-Bray and Counterſcarp; alſo Subtrenched.



C D is the Fauſſebray, and D M his Parapet: E F G H is the Subtrench, and I K the Covert-way. Laſtly, K L is the Argin or Parapet of the Counterſcarp. Note, That the Height of the Rampire A B ought to be raiſed 15 or 18 foot above the *Terra Plana*, although here it is but 12 foot, which is ſomewhat too low to command the Trench of Ditch: But if the Trench be made broader, then it will command the bottom thereof.

Of Irregular Fortification.

In the ſeventh Figure following let A B C D E be an Irregular Fort, containing 5 Baſtions, or Bulwarks. Firſt, we will make a Baſtion on the Angle at A, which do thus: Divide the Polygon Angle in half with the Line A F, and draw the Baſtion-Angle as formerly, being $\frac{2}{3}$ of the Polygon-Angle as A H, and A I continued, being the Sides whereon the Fronts muſt be laid down.

Now upon ſome ſpare Paper you ſhall make the half Polygon-Angle G A F, as you may ſee underneath this Figure, as L K M: Then make choice of the Capital Line, as before: let it be of any convenient length (larger than you think your Baſtion will be in the Figure) as underneath K N, and from N the Center of the Gorge draw a Parallel to K L, continued to O, as N P; and ſo proceeding as before, you ſhall find the Point of the ſecond Baſtion at O: So have you the Proportion of your Baſtions, whereby you may gain thoſe in the Figure.

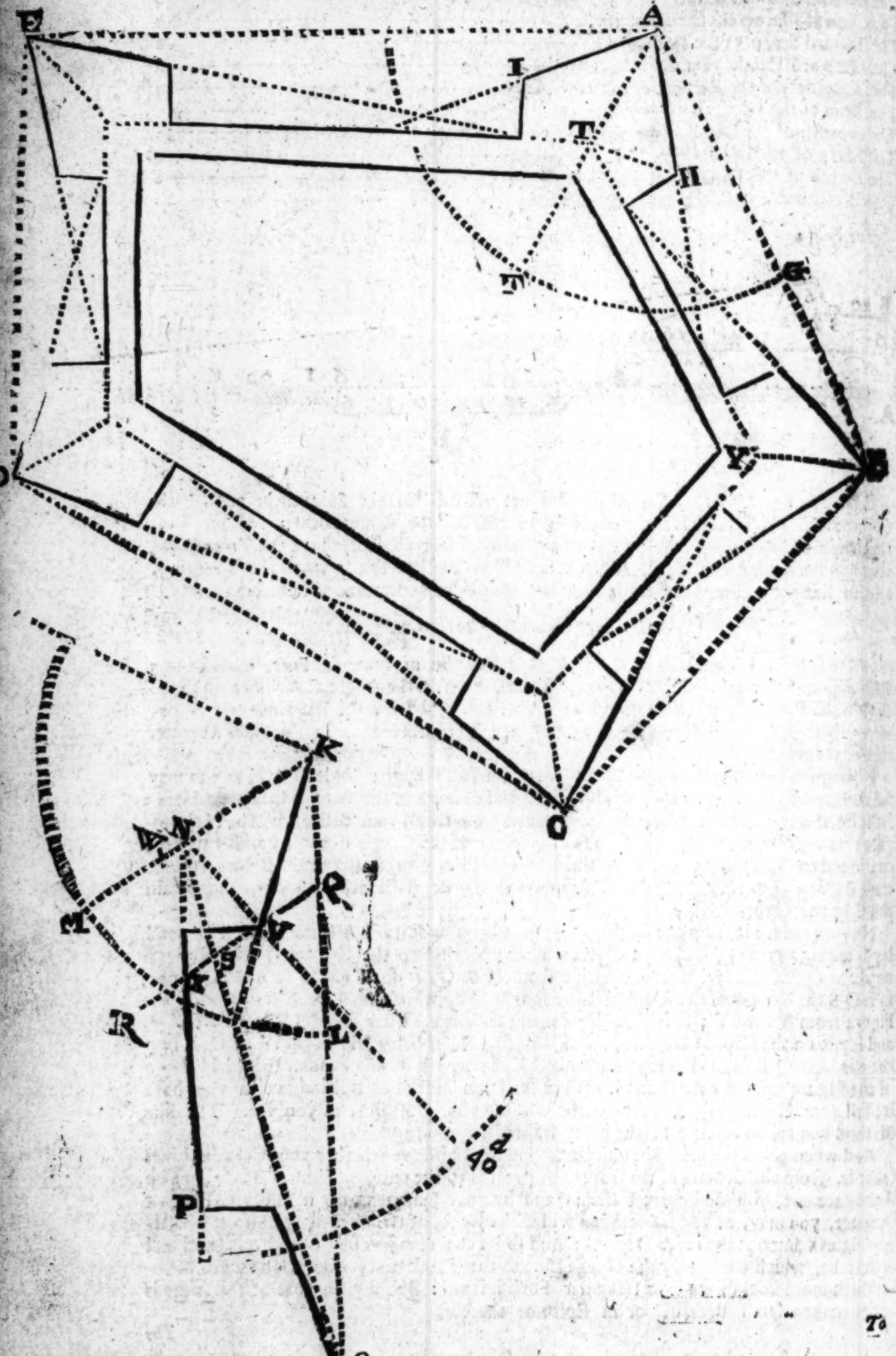
Now to reduce it from the Baſtion Point at A, you muſt take A B the ſhorteſt ſide and lay it from O unto Q; and from Q draw a Line parallel to the Capital Line K N continued, as Q R. Laſtly, drawing a Line from N to O, it ſhall cut Q R in the Point S; ſo is Q S the Length of the Capital Line ſought for, which muſt be laid down on the Figure from A unto T; ſo is T the Center of the Gorge. Then for the Front take K V, and lay it on the Capital Line from K to W; ſo a Ruler being laid from W to O, it ſhall cut the Line Q R in the Point at X; ſo is Q X the length of the Front, to be laid down in the Figure from A unto H and I. Thus ſhall you finiſh your Baſtion, when you have let fall your Flanks perpendicular on the ends of your Curtains, as you ſee. The like Method you are to obſerve for the other Baſtions.

And when you have finiſhed your Fort, you muſt obſerve whether your Curtain Lines (that is, from the Centers of the Gorge) be parallel to the outward Sides A B, &c. which if they are not, you muſt correct them; and by your Judgment, by help of the Lines of Defence, you may, as you ſee occaſion widen the Necks of the Gorges, and alſo the Baſtion Angles; but not above 90 Degrees: And ſo let the Flankers be as near proportional as may be, which commonly the Gorge Line to the Flank bears proportion as 7 to 6.

Much more could I write of Irregular Fortification: But my purpoſe at this time is but to make a ſmall Treatiſe, or an Epitome thereof.

The

The seventh Figure, of an Irregular Fort, containing 5 Bastions; being the Platform of the Royal Fort sometimes on St. Michael's Hill, *on the North-West side of the City of* Bristol.



To make a Scale for Fortification by the Tables.

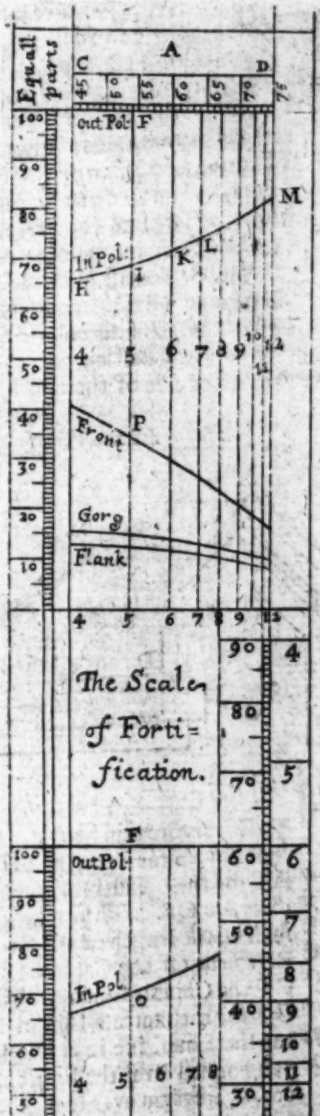
THis may be performed Geometrically by observing the former Instructions, whereby you may gain the length of every Line: But it will be sooner done, and more easy, by these Tables following.

First Table for 12 Sides.

Numb. of Sides.	4	5	6	7	8	9	10	11	12
Semi. Out. Pol.	1000	1000	1000	1000	1000	1000	1000	1000	1000
Semi. Inn. Pol.	661	700	731	756	777	795	810	823	834
The Front	412	347	299	261	232	209	190	174	160
The Gorge	158	151	141	132	123	115	108	101	96
The Flank	133	127	119	111	103	97	90	85	80

Second Table for 8 Sides.

Numb. of Sides.	4	5	6	7	8
Semi. Out. Pol.	1000	1000	1000	1000	1000
Semi. Inn. pol.	661	706	140	766	787
The Front	412	346	296	259	229
The Gorge	158	156	148	138	130
The Flank	133	131	124	116	109



Make your Scale of a sufficient length, that may hold both Lines, the one for 12 Sides, and the other for 8. Make choice within the breadth of the Scale, between the Borders, any sufficient breadth, as C D; from whence draw Parallels to the Sides, and divide C D into 30 equal parts, and begin your account from C with 45: So shall the end at D be 75 deg.

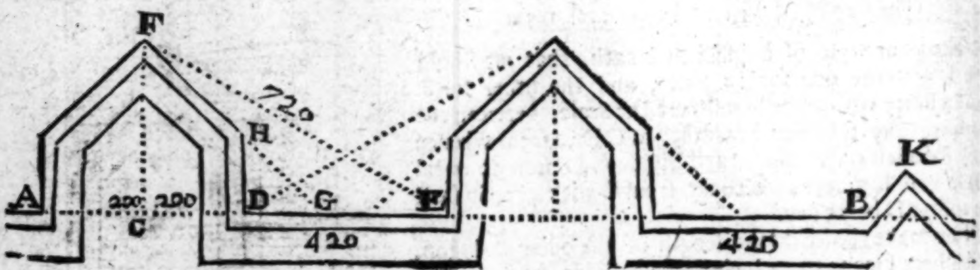
Now make choice of the length of the outer Polygon, which here I make three Inches; and divide a Line by the Side thereof, equal thereto, in 100 equal parts, and suppose each part into 10; so have you 1000 parts, agreeable to the Tables. The next thing is to draw Parallels to C E, according to the Polygon half Angles, as you may see in the Tables under the Pentagon Fort. So on the Scale C D you have for the half Angle of a Pentagon 54 Degrees, whereby you may draw the Pentagon parallel F G; and so in the lower Scale of 8 Baistons. In the like manner you may do for all the rest.

Now to draw the cross Lines for the Semidiameters of the inner Polygons, as also the Lines for the Fronts, Gorges, and Flanks, you shall work thus. First, you must note, That the Semidiameter of the outer Polygon is the Radius or whole Line of 1000 equal parts, and that is drawn at Right Angles at F: But for the Semidiameter of the inner Polygon, look in the Table of 12 Sides in the second Column under 4, you have 661. Take that Number off your Scale of equal parts, and lay it from E to H: Then in the third Column under 5, you have 700 parts; lay the same down from G to I, and make there a prick or point: Do the like for the Hexagon and Heptagon, as at I and K; proceeding along with all the rest unto the Dodecagon. And lastly, draw a Line through all those Points: So have you the Arch Line H M for the Semidiameters of the inner Polygon. In the same manner work for the Front, Gorge, and Flank Lines. The Scale of 8 Sides is made by the same Method.

I have also inserted on the left side of the Scale a line of Chords, whose Radius (or Chord of 60 deg.) is three Inches; and by it a Line for the Sides of the Polygons. The Hexagon, or six Sides, is equal to the Radius: And for the Tetragon, or four sides, it is equal to the Chord of 90 Degrees. So having described a Circle with the Chord of 60 Degrees, you shall find, that if you take from the Center N unto 5, it shall divide the Circle into 5 equal parts, for drawing the Figure of a Pentagon, which in the Figure of a Pentagon Fort, will reach from A to B, and so to X, Y, Z, and A. Now D A in the same second Figure you shall find to be the Semidiameter of the Outer Polygon, which in the Scale is G F, and taking G I off the Scale for 12 Bastions, or G O on the Scale of 8 Bastions, it will give the Semidiameter of the Inner Polygon, as D O in the same Figure. So likewise G P on the Scale will be equal to the Front A K in the Pentagon Fort. The like you may understand for laying down the Gorge and the Flank. And for the Curtain, as before, you must make R S 1 ½ the length of the Front A K.

This Scale will also be of good use in Irregular Fortification. As for instance, in the Irregular Fort, you shall find the half Bastion Angle G A F to be 58 Degrees, which falls on the Scale between the Pentagon and Hexagon, from whence you may draw a Bastion on some spare place, and from thence proportionate the same unto the outer side of the said Figure A B. The rest I leave to your own practice.

How to Fortify a long Curtain with Bulwarks, or a straight Town Wall.



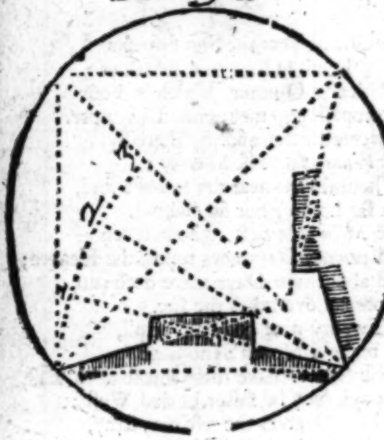
Let the Curtain be A B. First take 200 foot from the Scale of Fortification, accounting 10 for 100; and lay the same from A unto C, and from C unto D: So shall A D be the breadth of the Neck of the Gorge: and upon the Point C erect a Perpendicular, as C F. Then take 420 foot off your Scale, and lay the same from D to E, which shall be the length of the Curtain. Next you must take 720 foot, and lay the same from E, to cut off the Capital Line at F; so shall E F be the longest Line of Defence, and C F the Capital Line; which Line C F must be laid down from C unto G: and draw G F for the shortest Line of Defence. Lastly, upon D erect a Perpendicular, which will cut the same Line in H; so have you D H for the Flank, and H F the Front. Thus have you finished half the Bastion, from whence you may transport all the rest of the Bastions, were they ever so many.

Note, That these Bastions must not exceed 720 foot, that so it may not be without Musquet-shot. But if you will defend the Front with Cannon, you may make the Line of Defence almost twice so much. The like for the Curtain, which may be 800 foot; and in the middle of the Curtain you may make a Spur, or Point of a Bastion, as at K, which will be necessary for Musquet-shot, beside the Cannon; of which in the Line drawn about the City of *Bristol* I have seen many.

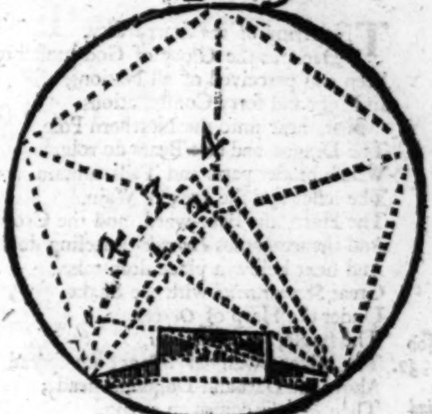
The

The five following Pieces are taken out of Malthus, *the Proportions you may find by the Scale, and the Rules before shewed.*

Tetragon

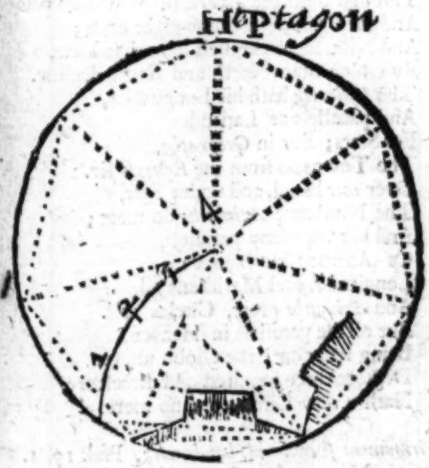


Pentagon

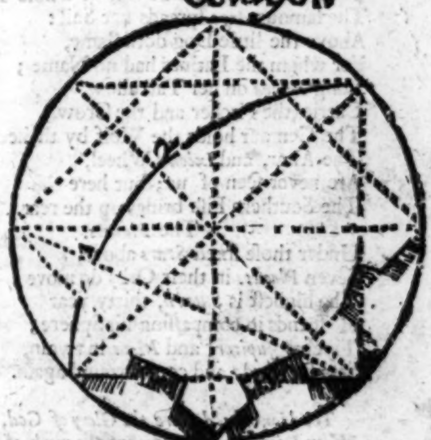


Hexagon

Heptagon



Octagon



The End of the Fifth Book.

Of the Eight and Forty Constellations of the Fixed Stars; and of the Circles of the Sphere.

THe Army of the Starry Sky,
Declares the Glory of God most high,
Seen and perceived of all Nations,
In Eight and forty Constellations.
* First, near unto the Northern Pole,
The Dragon and two Bears do role.
Whose hinder parts and Tails contain
The lesser and the greater Wain.
The Hare, the Bear-ward, and the Crown;
And thence comes *Hercules* kneeling down;
And next below a place doth take,
Great *Serpentarius* with the Snake.
Under the Harp of *Orpheus*,
The Eagle, and *Antinous*,
The Silver Swan her Wings doth spread
Above the Dart and Dolphin's head;
Then *Pegasus* comes on amain,
Andromeda follows in her Chain;
The Triangle below her stands,
And at her Feet in *Perseus*'s Hands
The *Gorgon*'s Head; above are seen
Her Parents, *Cepheus* with his Queen
Cassiope, not far below,
Heniochus his Goat doth show
On his left Shoulder, in his Hand
He doth the stormy Kids command.
Here in the *Zodiack* begins
The Ram (♈,) the Bull (♉,) the loving Twins (♊,)
The Crab (♋,) the Lion (♌,) and Virgin (♍,) tender;
The Ballance (♎,) Scorpio (♏,) and Bow-bender (♐,)
Goat (♑,) Water-Man (♒,) then Fishes twain (♓,)
Shall bring you round to the Ram (♈) again.
Fifteen Images appar
In the Southern Hemisphere,
The Monstrous Whale above the rest,
Eridanus wets his Breast.
Over the Hare *Orion* bright,
Sparkles in a cold Winters Night;
Then comes the great Dog, at whose Tail
The famous *Argo* spreads her Sail:
Above the little Dog doth flame,
For whom the Latines had no Name;
Long *Hydra* on her Tail allow,
Carries the Pitcher and the Crow;
The Centaur holds the Wolf by th' heel;
The Altar, and *Ixion*'s Wheel,
Are never seen of us; but here
The Southern Fish brings up the rear.

The Planets.

Under those fixed *Stars* above,
Seven *Planets* in their Orbs do move;
The highest is *Saturn*, thirty year
He spends in compassing his Sphere;
Twelve *Jupiter*, and *Mars* in twain,
Sets forward, and comes round again.
Then in one year the Sun displays
Three hundred sixty and five days;
And near a Quarter, which in Four
Encompassings, makes one Day more.
Between the Sun and us, there fly
Fair *Venus* and swift *Mercury*;
* These always near the *Sun* we find,
Not far before, nor far behind.
The *Moon* is lowest, who in seven
And twenty Days goes round the Heaven;
And about two Days more doth run,
Before she overtakes the *Sun*.
So Twenty nine and half in all,
Do make a Month Synodical.
These *Planets* make their course to th' East,
Though they be faster hurled West;
And six Degrees the rest may stray,
Besides the *Sun*'s Ecliptick way.

The Circles of the Sphere.

Six greater Circles mark you shall,
Which equally divide this Ball:
Just in the midst between the Poles,
From East to West the *Equator* roles.
The *Ecliptick* cuts him, and doth slide
Twenty three degrees and half a side,
Horizon even with the ground,
From Stars below our sight doth bound.
Meridian strait upright doth rise,
Parting the East and Western Skies.
Two Colours through the Poles do run
Quartring the Circle of the Sun;
One where the Spring and Fall begin;
Th' other where longest Days come in:
Four lesser Circles mark them well,
Are to th' *Equator* Parallel.
Two *Tropicks* bound the *Sun*'s high-way,
Shewing the longest and shortest Day,
The *Arctick* Circle cuts the Bears,
Th' *Antarctick* opposite appears.
Meridians half Twenty four,
For Hours, and for Degrees Ninescore,
Through both the *Poles* o'th' World do pass
And the *Equinoctial* down-right cross;
And Nine score parallels have that Line,
By which Stars North and South decline.
The *Ecliptick* hath his Longitudes,
And parallels of Latitudes
For Stars; But in *Geography*,
The Towns do from the *Equator* lie.
Over our Head, and under Feet,
The Ninescore *Azimuths* do meet;
And here as many parallels,
Of Altitude Horizontals
Longitudes and Meridians all,
And *Azimuths* great, Circles call.
But all the parallels in Heaven,
Being lesser cut, the Globe uneven.
Degrees three hundred and threescore
Hath every Circle, and no more.

* Job 38.31, 32. *Canst thou bind the sweet Influence of the* Pleiades, *or loose the Bonds of* Orion? *Canst thou bring forth the* Mazaroth *in his season, or canst thou guide* Arcturus *with his Sons.*

The Heavens declare the Glory of God, and the Firmament sheweth his handy-work, Psal. 19. 1.
When I consider the Heavens the work of thy Fingers, the Moon, and the Stars which thou hast ordained, what is Man, that thou art mindful of him? Or the Son of Man, that thou visitest him? Psal. 8. 3.

THE MARINER'S MAGAZINE;

OR,

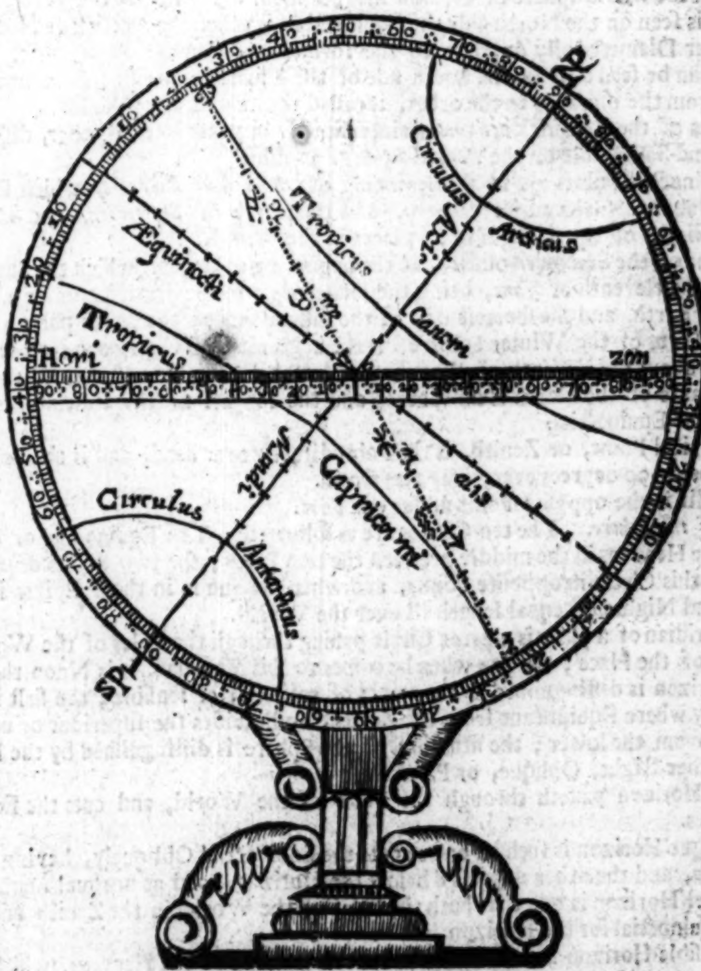
STURMY'S Mathematical and Practical

ARTS.

The Sixth BOOK.

Wherein is contained

The Definitions of the Circles of the Sphere, with the manner how to resolve divers necessary Astronomical Propositions both by Projection, (or the Scale and Compasses) and also by the Doctrine of Spherical Triangles, *&c.*



Felices animæ quibus hæc cognoscere primum
Inque domos superas scandere cura fuit.

CHAP. I.

Containing a definition of the Circles of the Sphere.

IN the former Books are contained such Problems Geometrical as are most necessary for every ingenious Artist to understand and practise: Now to the end the Practitioner may elevate his Thoughts to the contemplation of those glorious Bodies, the Sun, Moon, and Stars; I shall here in this place exhibit a brief survey of the first Rudiments of *Astronomy*, for the help of young Practitioners and Mariners, for whom chiefly I take this pains: I shall give a brief and succinct Explanation of the several Circles of the Sphere, and then shew how to resolve the most usual and common Problems thereof.

This is to be understood, that Astronomers do imagine ten principal Points, and ten Circles to be in the Convex side of the first Moveable Sphere, which are commonly drawn upon every Globe or Sphere, besides divers other Circles which are not delienated, but only conceiv'd by the Mind.

The Points are the two Poles of the World, the two Poles of the Ecliptick, the two Equinoctial Points, the two Solistitial Points, and the *Zenith* and *Nadir*.

The Poles of the World are two Points, which are directly opposite to one another, about which the whole Sphere of Heaven moveth from the East to the West, whereof that which is seen on the North-side the Equinoctial, is called the Arctick or North Pole.

The other Diametrically opposite to the former is called the Antarctick, or South Pole, and can be seen only on the South-side of the Equator; a right Line imagined to be drawn from the one Pole to the other, is called the Axis of the World.

The Poles of the Ecliptick are two Points directly opposite to each other, distant from the North and South Pole of the World 23 deg. 31 min.

The Equinoctial Points are in the beginning of *Aries* and *Libra*, to which Points the Sun cometh about the eleventh of *March*, and thirteenth of *September*, and makes the Days and Nights of equal length in all places in the World.

The Point of the Summer Solistice, is the beginning of Cancer, which the Sun cometh unto about the eleventh of *June*, being the longest day to the Inhabitants on the North part of the Earth, and the shortest day to the Inhabitants of the South part.

And the Point of the Winter Solstice, is the beginning of Capricorn, to which the Sun cometh about the eleventh of *December*, and maketh the shortest day of the year to the Inhabitants of the North Hemisphere, and the longest to the Inhabitants on the South-side the Equinoctial.

The Vertical Point, or Zenith, is the Point directly over head, and is the Pole of the Horizon, being 90 degrees every way therefrom.

The Nadir is the opposite Point under our Feet.

Circles of the Sphere. The ten Circles are as followeth; The Equinoctial or Equator, dividing the Heavens in the middle between the two Poles; the two Points of Aries and Libra, cut this Circle in opposite Points, and when the Sun is in those Points it makes the Days and Nights of equal length all over the World.

The Meridian of a place is a great Circle passing through the Poles of the World, and the Zenith of the Place; the Sun when he comes to this Meridian, it is Noon there.

The Horizon is distinguished by the names of rational, or sensible; the first is a great Circle every where Equidistant from the Zenith, and divides the superiour or upper Hemisphere, from the lower; the situation of the Sphere is distinguished by the Horizon, which is either Right, Oblique, or Parallel.

A right Horizon passeth through the Poles of the World, and cuts the Equator at right Angles.

An Oblique-Horizon is such an one as cuts the Equinoctial Obliquely, having one Pole rais'd above, and the other depress'd below the Horizon, and at unequal Angles.

A Parallel-Horizon is one that hath the Poles of the World in the Zenith and Nadir, and the Equinoctial for the Horizon.

The Sensible-Horizon is a Circle that divideth the part of the Heavens, which we see, from the part we see not, called the Finitor.

The Ecliptick is a great Circle, that divides the Equator into two equal parts; the Points of Intersection are Aries and Libra, the one half declining toward the North, the other to the South 23 degrees 31 min.

From

From the Ecliptick the Latitude of the fixed Stars and Planets are number'd both Northward and Southward; the Circumference of this Circle containing 360 deg. is divided into twelve equal parts called Signs, every Sign containeth 30 degrees, and every degree containeth 60 minutes, and every minute 60 seconds, and every second 60 thirds.

The Names and Characters of the 12 Signs.

♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
Aries.	*Taurus.*	*Gemini.*	*Cancer.*	*Leo.*	*Virgo.*	*Libra.*	*Scorpio.*	*Sagittarius.*	*Capricornus.*	*Aquarius.*	*Pisces*

The Six first are Northern, and Six last the Southern Signs.

Of the Colures. These are two great Circles, (or Meridians) passing through the Poles of the World, crossing one the other at right Angles, and dividing the Equinoctial and the Ecliptick into four equal parts, making thereby the four Seasons of the Year.

The Solstitial Colure is a great Circle passing through the Poles of the World, the Poles of the Ecliptick and the Solstitial Points of Cancer and Capricorn, shewing the middle of Summer and Winter.

The Equinoctial Colure, is a Circle passing by the Poles of the World through both the Equinoctial Points of Aries and Libra, shewing the beginning of the Spring and Autumn, when Days and Nights are equal.

The Tropick of Cancer is a lesser Circle of the Sphere, equi-distant from the Equinoctial to the Northward 23 degrees 31 min. wherein when the Sun is, then he enters Cancer, and makes his greatest Northern Declination.

The Tropick of Capricorn is a lesser Circle, equi-distant from the Equinoctial Southward 23 degrees 31 min. to which when the Sun cometh, he then enters Capricorn, and maketh his greatest Southern Declination.

Of the two Polar Circles. These are two lesser Circles, distant as much from the Poles of the World, as the Tropick of Cancer and Capricorn is from the Equinoctial in which are the Poles of the Ecliptick, which moving about the Poles of the World, describe by their motion the said two Circles; that about the North-Pole is the Arctick Circle, and that about the South is the Antarctick Circle.

The first six are called Circles, and the other four lesser Circles; by the Centre of a Circle is meant a Point or Prick in the middle of a Circle, from whence all Lines drawn to the Circumference are equal, and are known by the names of Radius or Semidiameters.

That is said to be a great Circle, which hath the same Centre as the Sphere, and divides it into two equal halfs, called *Hemispheres*; and that is a lesser Circle, which hath a different Centre from the Centre of the Sphere, and divides the Sphere into two unequal Portions or Segments.

Of other Circles imagined, but not described in a material Sphere or Globe.

Such are the Azimuths, Almicanters, Parallels of Latitude and Declination.

Azimuth or Vertical Circles pass through the Zenith, and intersect the Horizon at right Angles; and the Azimuth of East and West is called the Prime Vertical.

The Sun or any Star having Elevation or Depression above or below the Horizon, is then properly said to have Azimuth; but if they be in the Horizon, either rising or setting, the Arch of the Horizon between the Centre of the Sun or Star, and the Point of East or West, is called the Amplitude.

Circles of Altitude, called Almicanters, are Circles Parallel to the Horizon, and intersect the Vertical Circles at right Angles, which are greatest near the Horizon, and lesser towards the Zenith, in which Circles the Altitude of the Sun, Moon, or Stars above the Horizon are accounted, which is an Arch of an Azimuth, contained betwixt the Almicanter, which passeth through the Centre of the Sun, Moon, or Stars, and the Horizon.

Parallels of Declination are lesser Circles, all Parallel to the Equinoctial, and may be imagined to pass through every degree and part of the Meridian, and are described from the Poles of the World; in like manner, the Declination of the Sun or a Star is measured by the Arch of the Meridian between the Sun and Star, and the Equinoctial.

Parallels of Latitude in the Heavens, are lesser Circles described from the Poles of the Ecliptick, and serve to define the Latitude of a Star, which is the Arch of a Circle contained betwixt the Centre of any Star or Planet, and the Ecliptick Line, (making right Angles therewith) and counted toward the North or South Poles of the Ecliptick, and the Sun ever keeps its way under the Ecliptick-Line, and therefore hath no Latitude.

The

The Longitude of the Sun or Stars is measured by the Arch of the Ecliptick, comprehended between the Point of Aries, and a great Circle passing from the Poles of the Ecliptick, by the Sun or Stars Centre, and reckon'd according to the succession of the Signs.

Longitude on the Earth, is an Arch of the Equinoctial contained between any assigned Meridian where it begins, and the Meridian of any other place, accounted Eastward from the first place; but in my Tables it is counted East and West from the Meridian of the *Lizard* terminating at 180 Degrees.

Right Ascension is an Arch of the Equinoctial (accounted from the beginning of Aries) which cometh to the Meridian with the Sun, Moon, or Stars, or any part of the Ecliptick; and by it there are Tables made for the Sun, Moon, and Stars to know the time of their coming to the Meridian.

Oblique Ascension is an Arch of the Equinoctial between the beginning of Aries and that part of the Equinoctial, that riseth with the Centre of the Sun or Star, or any portion of the Ecliptick in an Oblique Sphere.

Ascensional-difference is the Difference between the Right-Ascension, and the Oblique Ascension, and thereby is measured the time of the Sun or Stars rising or setting before or after Six.

Elevation of the Pole is the height thereof above the Horizon, which is equal to the distance between the Zenith and the Equinoctial, whose Complement is equal to the distance of the Zenith from the North or South Pole, or the Elevation of the Equator above the Horizon; these Circles I have inserted, to the end they may be perfectly known; for without them, the Reader cannot well understand the following Ploblems of the Sphere that are depending thereon.

CHAP. II.

The Projection of the Sphere in Plano, represented by the Analemma.

THe Sphere may be projected in Plano the Parallels being straight Lines, as in the Analmma, if the Semi-diameters of the Parallels be divided in such sort as the Line of Sines.

This Scheme is fitted for the Latitude of 51 deg. $\frac{1}{2}$, and represents the Points and Circles of the Sphere before described.

The Projection. Take with your Compasses the Chord of 60 degrees, and upon the Centre C describe the Circle H Z O n (2.) Draw the Diameter H C O which represents the Horizon, and at Right-Angles thereunto, cross it with another Diameter Z C N.

Then for the Latitude of the place, prick off 51 deg. $\frac{1}{2}$ from O to N, and from H to S; and from the same Line of Chords, take the Complement of the Latitude 38 deg. $\frac{1}{2}$ and prick it off from H to Æ, and from O to Q, and draw N C S and Æ C Q.

Then take the Suns greatest Declination 23 deg. $\frac{1}{2}$ and prick off from Æ to G and T, and with the like Chord do the same from N to y and *g*, for the Polar-Circle; and the like do from Q to D and P, and from S to X and ħ; and through these Points draw Parallels to the Equator y *g*, T S D, G *b* P, and X ħ.

And through the Centre draw the Ecliptick-Line T C P; and draw R S Parallel to the Horizon H C O, and any other Parallel of Altitude as I *f*.

Thus are the Points before defined, represented in this Diagram; N is the North-Pole, S the South-Pole, *g* the North, X the South-Pole of the Ecliptick; C the Equinoctial-Points of *Aries* and *Libra*; T the Point of the Summer-Solstice, P the Point of the Winter-Solstice, Z the Zenith over our Heads, n the Nadir-points under our Feet.

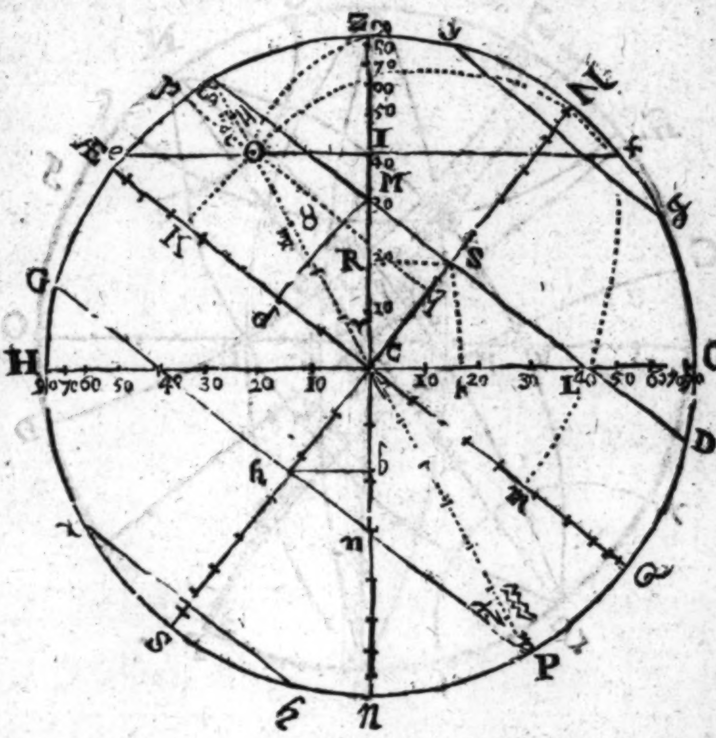
The greater Circles are H C O the Horizon, Z C n the prime Vertical or Azimuth of East and West; H Z O n the primary Meridian, and also the Colure of the Summer and Winter Solstice, Æ C Q the Equinoctial; T C P the Ecliptick; S C N the Hour-Circle of 6; and also it represents the Colure of the Equinoxes.

The lesser Circles are also represented, T D the Tropick of Cancer; G P the Tropick of Capricorn; y *g* the Arctick-Circle, about the Pole North, X ħ the Antarctick-Circle.

Other Circles not described upon Globes, are there represented; *e f* represents a Parallel of Altitude, called an Almicanter; the prickt Arch Z ⊙ represents an Azimuth.

The

The Projection of the Sphere in Plano, *according to the* Analemma.



The prickt Arches from the Poles represent the Meridian or Hour-Circles, which are Ellipses; the drawing thereof will be troublesom, and for that reason is not mentioned; and how to shun them in the resolution of any Proposition of the Sphere, by Chords shall be shewn in the several Questions following; But the Sphere may be Projected in *Plano*, by Circular-Lines, as in the general Astrolobe of Gemma Frisius by help of the Tangets and ½ Tangents on the Scale as in the fourth Book beforegoing, and will resolve the same things.

In this Projection the Circles are distinguished by the same Letters as in the Analemma.

Circles drawn Parallel to the Equinoctial ÆQ, as *pq*, TD, Y*g*: represent Parallels of Declination. Circles drawn Parallel to the Ecliptick TP, represent Parallels of Latitude of the Stars or Planets. Arches relating to the motion of the Sun, in either Projection are as follows.

(1.) The Suns Amplitude, or Coast of Rising and Setting from the East and West, is represented by C L in Northern Sines, and by C F in Southern Sines.

(2.) The Ascensional-difference, or time of Rising and Setting from six, in Summer by S L, in Winter by *Fh*.

(3.) The Altitude at Six in Summer, by R C, and his Depression at Six in Winter by C*b*.

(4.) The Azimuth at the hour of Six in Summer, by R S, or C*f*, equal to *b b* in Winter.

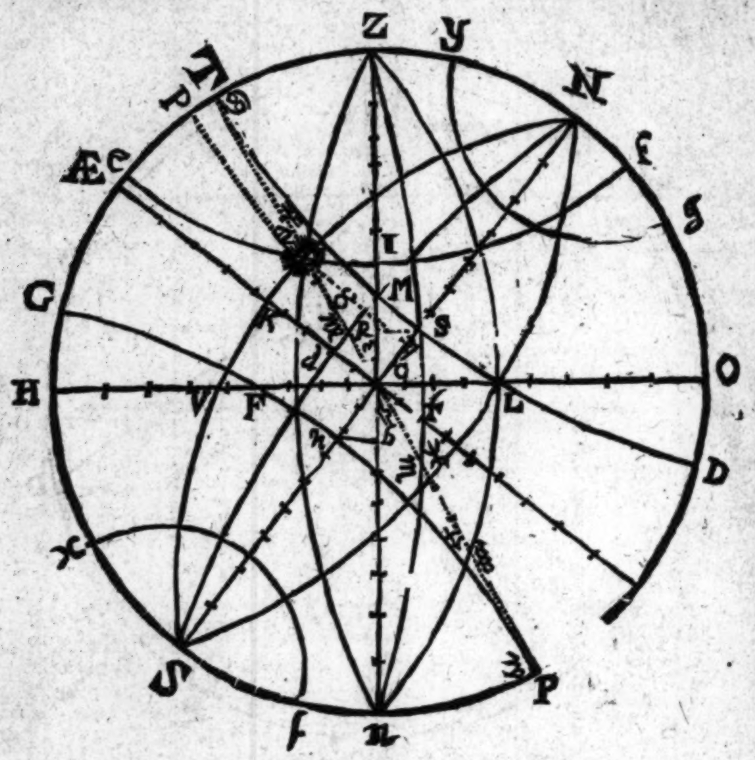
(5.) The Vertical-Altitude or Altitude of East and West, by M C, in Summer, and his Depression therein in Winter by C N.

(6.) The hour from Six, being East and West, in Summer by M S, in Winter by N *b*.

(7.) The Azimuth from the East or West upon any Altitude, is represented in the Parallel of Altitude, where it intersects the Parallel of Declination by I ☉.

(8.) The hour of the Day from Six, to any Altitude, is always represented in the said Point of Intersection, in the Parallel of Declination, as by *q* ☉. This Projection

The Projection of the Sphere by Circular Lines, called the Stereographick *Projection.*



of the Sphere doth represent the Triangles commonly occurring in Astronomical Problems. Thus the Right-Angled Triangled C K ⊙, Right-Angled at K, (supposing the Sun at ⊙,) is made of C K his right Ascension, ⊙ K his Declination, and K C ⊙ the Angle of the Ecliptick, with the Equinoctial (being the Suns greatest Declination 23 deg. 31.) C ⊙ K the Angle of the Suns Meridian and Ecliptick, and C ⊙ the Suns distance from the Equinoctial Point ♈ or ♎. In the Right-Angled Triangle L O N, Right-Angled at O; supposing the Sun at L O N is the Elevation of the Pole, N L the Complement of the Suns Declination, L O the Suns Azimuth from the North, L N O the Hour from Midnight, (or Complement of the Ascensional Difference) N L O the Angle of Position, that is, of the Suns Meridian with the Horizon; and of the like parts, or their Complements, is made the Triangle C M L. In the Right-Angled Triangle C h S, Right-Angled at h; supposing the Sun at S, there is given C S his Declination, and his Altitude at the hour of six, C h the Suns Azimuth from the East and West at the hour of six, h C S the Angle of the Poles Elevation, C S h the Angle of the Suns Position. In the Right-Angled Triangle C d M, suppose the Sun at M; d M the Suns Declination, C d the hour from six, C M the Altitude being East or West, d C M the Latitude, d M C the Angle of the Suns Position. In the Oblique-Angled Triangle Z ⊙ N, if the Sun be ⊙, Z N is the Complement of the Latitude, and N ⊙ the Complement of the Suns Declination, or distance from the Pole, Z ⊙ the Complement of the Suns Altitude; Z N ⊙ the Angle of the Hour from Noon; N Z ⊙ the Suns Azimuth from the North part of the Meridian; Z ⊙ N the Angle of the Suns Position.

CHAP. III.

How to calculate the Sun's place in the Ecliptick.

THis proposition is propounded, in the first place, because many others depend upon it, there is ascribed to the Sun a Triple Motion; first, a Motion upon his own Axis, whereby he finisheth one Revolution in 26 Days.

2. A

A Table of the Suns Mean Motion.

The Epocha or Radix.	Longit. ☉				Apog. ☉			
Years	S	D	M	S	S	D	M	S
[illegible]	9	07	59	51	2	08	20	03
[illegible]	9	19	48	55	3	05	22	55
[illegible]	9	19	57	54	3	05	43	28
[illegible]	9	20	06	52	3	06	04	00
[illegible]	9	20	15	51	3	06	24	33
[illegible]	9	20	24	49	3	06	45	05
[illegible]	9	20	33	48	3	07	05	38

☉ Mean Motion in Years above 20.

Years	S	D	M	S	S	D	M	S
[illegible]	0	00	08	59	0	00	20	33
[illegible]	0	00	17	57	0	00	41	05
[illegible]	0	00	26	56	0	11	01	38
[illegible]	0	00	35	54	0	11	22	10
[illegible]	0	00	44	53	0	11	42	43
[illegible]	0	01	29	45	0	03	25	26
[illegible]	0	02	14	38	0	05	08	08
[illegible]	0	02	59	31	0	06	50	51
[illegible]	0	03	44	23	0	08	33	34
[illegible]	0	04	29	16	0	10	16	17
[illegible]	0	05	14	09	0	11	59	00
[illegible]	0	05	59	01	0	13	41	42
[illegible]	0	06	43	54	0	15	24	25
[illegible]	0	07	28	47	0	17	07	08
[illegible]	0	14	57	34	1	04	14	15
[illegible]	0	22	26	21	1	21	21	22
[illegible]	0	29	55	08	2	08	28	30
[illegible]	1	07	23	55	2	25	35	37
[illegible]	1	14	52	42	3	12	42	44

☉ Mean Motion in Years under 20.

	Years	Longit. ☉				Ap. ☉	
		S	D	M	S	M	S
	1	11	29	45	40	1	02
	2	11	29	31	20	2	04
	3	11	29	16	59	3	05
L	4	00	00	01	48	4	07
	5	11	29	47	28	5	08
	6	11	29	33	07	6	10
	7	11	29	10	47	7	12
L	8	00	00	03	35	8	13
	9	11	29	49	15	9	14
	10	11	29	34	55	10	16
	11	11	29	20	35	11	18
L	12	00	00	05	23	12	20
	13	11	29	51	03	13	21
	14	11	29	36	43	14	23
	15	11	29	22	23	15	25
L	16	00	00	07	11	16	26
	17	11	29	52	51	17	28
	18	11	29	38	31	18	29
	19	11	29	24	10	19	31
L	20	00	00	08	59	20	33

☉ Mean Motion in Months.

Jan.	00	00	00	00	00	00
Feb.	01	00	33	18	00	05
March	01	28	09	11	00	10
April	02	28	42	30	00	15
May	03	28	16	39	00	20
June	04	28	49	58	00	25
July.	05	28	24	07	00	31
Aug.	06	28	57	25	00	36
Sept.	07	29	30	44	00	42
Octob.	08	29	04	54	00	47
Novemb.	09	29	38	12	00	53
Dec.	10	29	12	22	00	59

The Calculation. Apog. ☉

	Longit. ☉ S D M S	S D M S
The Epocha. 1581.	9 19 48 55	3 5 22 55
Years added 2	11 29 31 20	2 44
March.	1 28 9 11	10
Days 13	12 48 49	2
Hours 23	56 40	0
Minutes 8	20	0
☉ Mean Motion.	0 1 15 15	3 5 25 11
Apogeum Subtract.	3 5 25 11	
The Anomaly of ☉	8 25 50 04	
The Equat. added to the Mean Mot.	2 2 51	
Gives ☉ true place,	♈ 3 18 6	
Agreeing with the Observation.	♈ 3 17 40	

(3.) Example, the time given the *10th* of *April* 1665 at Noon; and by the former Rules we have found the Suns Mean Motion 29 *deg.* 0 *min.* 30″, his Apogeum 3 *s.* 6 *d.* 49 *m.* 29″, his Anomaly 9 *s.* 22 *d.* 11 *m.* 1″.

And to find a Proportional part for the Equator proceed thus.

The Equat. answering to 22*d.* is 1*d.* 52*m.* 22″
The Equator answer. to 23*d.* is 1*d.* 51*m.* 29″

their difference ——————— 53

Then I say, if 1 *deg.* or 60 *min.* give 53″, what shall 11 *min.* give? By the Rule of Proportion,

60 : 53 11
11
———
53
53
———
583

(4
58(3 9 0$\frac{4}{5}$!
6

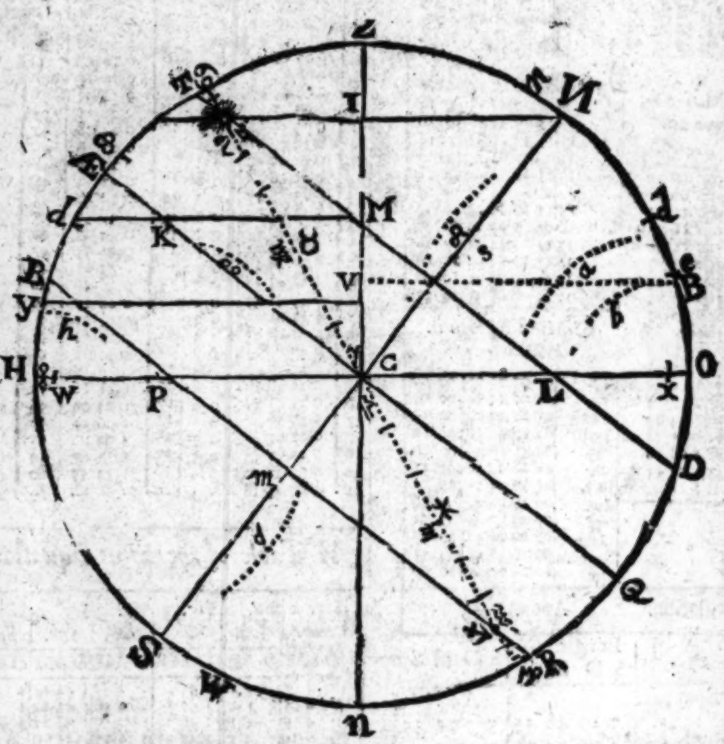
A Table of the Suns Mean Motion.

Days.	Longit. ☉				Apo.		H	Long. ☉			M	Lon. ☉	
	S	D	M	S	M	S		D	S	M		M	S
1	0	0	59	08	0	0	1	0	2	28	31	1	17
2	0	01	58	17	0	0	2	0	4	56	32	1	19
3	0	02	57	25	0	0	3	0	7	24	33	1	21
4	0	03	56	33	0	1	4	0	9	51	34	1	24
5	0	04	55	42	0	1	5	0	12	19	35	1	26
6	0	05	54	50	0	1	6	0	14	47	36	1	29
7	0	06	53	58	0	1	7	0	17	15	37	1	31
8	0	07	53	07	0	1	8	9	19	43	38	1	34
9	0	08	52	15	0	1	9	0	22	11	39	1	36
10	0	09	51	23	0	2	10	0	24	38	40	1	39
11	0	10	50	31	0	2	11	0	27	6	41	1	41
12	0	11	49	40	0	2	12	0	29	34	42	1	43
13	0	12	48	49	0	2	13	0	32	2	43	1	46
14	0	13	47	57	0	2	14	0	34	30	44	1	48
15	0	14	47	05	0	2	15	0	36	58	45	1	51
16	0	15	46	13	0	3	16	0	39	25	46	1	53
17	0	16	45	22	0	3	17	0	41	53	47	1	56
18	0	17	44	30	0	3	18	0	44	21	48	1	58
19	0	18	43	38	0	3	19	0	46	49	49	2	01
20	0	19	42	47	0	3	20	0	49	17	50	2	03
21	0	20	41	55	0	3	21	0	51	45	51	2	06
22	0	21	41	03	0	4	22	0	54	13	52	2	08
23	0	22	40	12	0	4	23	0	56	40	53	2	11
24	0	23	39	20	0	4	24	0	59	8	54	2	13
25	0	24	38	28	0	4	25	1	01	36	55	2	16
26	0	25	37	37	0	4	26	1	04	04	56	2	18
27	0	26	36	45	0	4	27	1	06	22	57	2	20
28	0	27	35	53	0	5	28	1	09	00	58	2	23
29	0	28	35	02	0	5	29	1	11	27	59	2	25
30	0	29	34	10	0	5	30	1	13	55	60	2	28
31	0	00	33	18	0	5	M	m.	se.	th.	se.	se,	th.

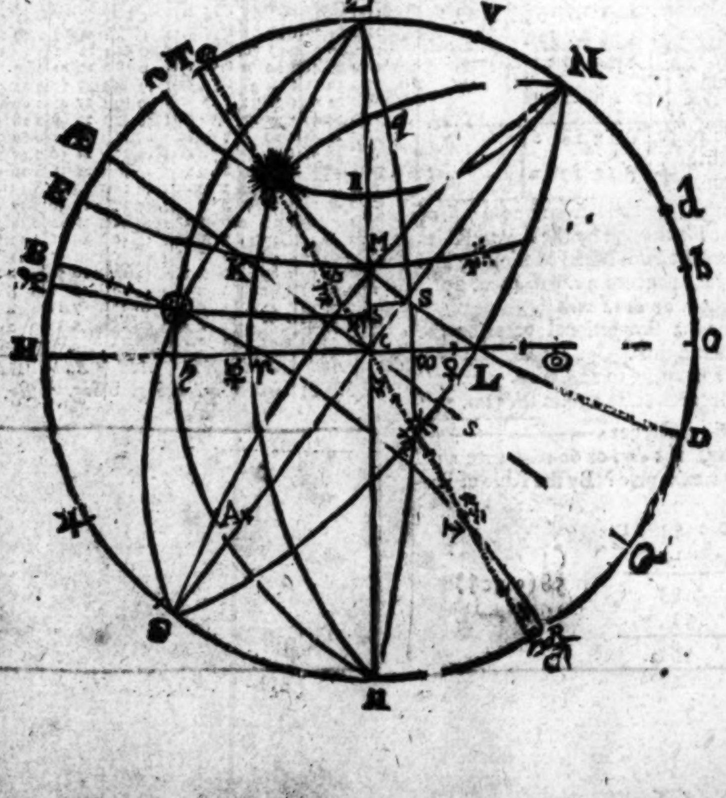
A Table of the Suns Equation.

	Sig. 0 Sub.			Sig. 1 Sub.			Sig. 2 Sub.			Sig. 3 Sub.			Sig. 4 Sub.			Sig. 4 Sub.			
	D	M	S	D	M	S	D	M	S	D	M	S	D	M	S	D	M	S	
0	0	0	0	0	59	32	1	41	2[illegible]	2	2	54	1	48	25	1	3	26	30
1	0	2	5	1	1	21	1	45	3[illegible]	2	2	56	1	47	20	1	1	32	29
2	0	4	9	1	3	10	1	46	38	2	2	56	1	46	15	0	59	37	28
3	0	6	12	1	4	57	1	47	41	2	2	55	1	45	9	0	57	40	27
4	0	8	16	1	6	42	1	48	40	2	2	52	1	44	1	0	55	42	26
5	0	10	19	1	8	26	1	49	38	2	2	47	1	42	50	0	53	43	25
6	0	12	22	1	10	9	1	50	34	2	2	39	1	41	37	0	51	43	24
7	0	14	25	1	11	51	1	51	29	2	2	29	1	40	22	0	49	42	23
8	0	16	28	1	13	32	1	52	22	2	2	17	1	39	4	0	45	39	22
9	0	18	30	1	15	11	1	53	13	2	2	2	1	37	45	0	45	35	21
10	0	20	32	1	16	49	1	54	1	2	1	46	1	36	24	0	43	31	20
11	0	22	34	1	18	26	1	54	43	2	1	29	1	35	3	0	41	26	19
12	0	24	37	1	20	02	1	55	31	2	1	7	1	33	39	0	39	20	18
13	0	26	39	1	21	36	1	56	14	2	0	44	1	32	2	0	37	14	17
14	0	28	41	1	23	9	1	56	55	2	0	18	1	30	44	0	35	6	16
15	0	30	42	1	24	41	1	57	34	1	59	49	1	29	13	0	32	58	15
16	0	32	43	1	26	11	1	58	10	1	59	19	1	27	41	0	30	50	14
17	0	34	44	1	27	40	1	58	44	1	58	47	1	26	7	0	28	41	13
18	0	36	43	1	29	8	1	59	16	1	58	12	1	24	32	0	26	31	12
19	0	38	41	1	30	34	1	59	46	1	57	35	1	22	56	0	24	21	11
20	0	40	38	1	31	58	2	0	14	1	56	56	1	21	18	0	22	10	10
21	0	42	35	1	33	20	2	0	40	1	56	14	1	19	38	0	19	59	9
22	0	44	31	1	34	41	2	1	04	1	55	30	1	17	56	0	17	48	8
23	0	46	27	1	36	0	2	1	26	1	54	44	1	16	12	0	15	36	7
24	0	48	22	1	37	17	2	1	46	1	53	56	1	14	26	0	13	33	6
25	0	50	16	1	38	33	2	2	3	1	53	5	1	12	40	0	11	10	5
26	0	52	09	1	39	48	2	2	18	1	52	12	1	10	52	0	8	57	4
27	0	54	1	1	41	1	2	2	30	1	51	18	1	9	2	0	6	43	3
28	0	55	52	1	42	12	2	2	40	1	50	21	1	7	11	0	4	29	2
29	0	57	42	1	43	21	2	2	48	1	49	23	1	5	18	0	2	15	1
30	0	59	42	1	44	28	2	2	54	1	48	22	1	3	36	0	0	0	0
	Add Sig. 11			Add Sig. 10			Add Sig. 9			Add Sig. 8			Add Sig. 7			Add Sig. 6			

The Projection by the Analemma appertaining to the thirteen Problems following.



The Stereographick Projection appertaining to the thirteen Problems following.



1. A

2. A dayly motion from the East into the West, by means of the *Primum Mobile*, whereby he causeth the Day and Night.

3. An opposite Motion from the West into the East, called the Annual Motion, whereby he runs once in a Year through the Ecliptick, moving near a degree in a day, and thereby causeth the several Seasons of the Year.

The two latter Motions may be represented by a man turning a Crane-Wheel, 365 times round, while a Worm creeping against, and contrary to that Motion, creeps once round the contrary way, but Obliquely; that is, from the further side of the Wheel, towards the hithermost; and by this Motion the Sun is supposed to describe the Ecliptick-Line, according to *Tycho*; and the other Planets, (except the Moon) moving round him, being subject to his Motions, and many of their own besides; many of which Motions are removed by the Copernican supposition of the Earths Motion, which is a subject of much controversy among the Learned: However, be it either the one, or the other, the Propositions hereafter resolved, vary not; the Proposition is what Longitude the Sun hath from the nearest Equinoctial Point, which may be found within a degree or two from the day of his Entrance into each Sign.

The Day of the Month the Sun enters into each Sign.		
	♈ Aries, *March* 10.	♎ Libra, *September* 13.
	♉ Taurus, *April* 10.	♏ Scorpio, *October* 13.
	♊ Gemini, *May* 11.	♐ Sagittarius, *Novemb.* 12.
	♋ Cancer, *June* 11.	♑ Capricornus, *Decemb.* 11.
	♌ Leo, *July* 13.	♒ Aquarius, *January* 10.
	♍ Virgo, *August* 13.	♓ Pisces, *February* 8.

1. If the Number of the Day of the Month given, exceed the Number of that day, in which the Sun enters into any Sign; Subtract the lesser Number from the greater, and the Remainder is the Degree of that Sign the Sun possesseth.

PROB. I. On *May* 12, I would find the Suns true place by the former Rules; the Sun enters Gemini, *May* 11; which subtract from 12, the Remainder is 1, which shews the Sun to be in 1 deg. of Gemini.

Example. Let it be required to know the Suns place the fourth of *November*; on the 11*th* day of that Month the Sun enters Sagittarius, and the 13*th* Day of *October* he enters Scorpio, betwixt the 13*th* of *October*, and the 4*th* of *November* are 22 Days, and consequently the Suns place is 22 deg. of Scorpio. But to find the Suns place by *Wing's Hypothesis*, and Tables in *Astronomia Britannica*, the Rule is. First, enter the Table of the middle Motion and Apogee of the Sun, and write out the Epocha next going before the time given, under which set the Motion belonging to the Years, Months, Days, Hours, and Minutes, (only in the Bissextile or Leep-years,) after *February* a Day is to be added to the number of days given; then adding them all together, the Sum will be the Middle-Motion and Apogee of the Sun for the time given.

Example. Suppose the 12*th* of *May* at Noon 1667, the Suns place is required.

Time given.	Longitude ⊙				Apog. ⊙			
	S	D	M	S	S	D	M	S
The *Epocha*.	9	20	24	49	3	6	45	5
1661, Years in-	11	29	33	07	0	0	6	10
cluding 6, *May*	3	28	16	39				20
Days 12.	0	11	49	40				2
The Suns Mean-motion, or Longitude.	2	00	04	15	3	6	51	37

2. Subtract the Apog. of the Sun from his Mean-Longitude, and the Remain will be his Mean Anomaly.

Example.	S	D	M	S
The Suns Mean-Longitude is	2	00	04	15
The *Apogæum* subtracted	3	06	51	37
The Suns Anomaly	10	23	11	38

With the Suns Anomaly enter the Table of his Equation with the Sign on the Head and the deg. descending on the left hand, if the number thereof be under 6 Signs; but if

if it be more than 6 Signs, enter with the sign in the bottom, and the deg. ascending on the right hand, and in the common-Angle you have the Equation answering thereunto; you may, (if need require,) take the Proportional part.

Example.

	S	D	M	S
In the Table of Equation answering to 23 deg. 12 min. 38 S. is	0	01	11	31
The Suns Mean-Longitude, add	2	00	04	15
The Suns true Longitude.	2	01	15	46

Therefore the true place of the Sun is in 1 deg. 15 min. 46 seconds of Gemini.

Example. In the Year 1583, *March* 14 at Noon, in the Meridian of *Vraniburg* in *Denmark*, the thrice noble *Ticho-Brahe*, observed the Suns true place in 3 deg. 17 min. 40 seconds of Aries. The time at *London* was *March* 13, 23 h. 8 m.

Multiply 53 by 11, the Product is 583, which divide by 60, the Quotient will be 9″$\frac{43}{60}$, or 10″, and because the Equation decreases, I subtract it from the Equator, answering to 22 deg. and it leaves 1 deg. 52 min. 12″, for the true Equation desired, which according to the Title, being added to the Suns Mean Longitude, giveth the true place of the Sun required, as follows:

	S	D	M	S
The Suns Mean-Longitude	0	29	00	30
The Equation added		1	52	12
The Suns true Longitude	1	00	52	42

Therefore the Suns true place is in 0 deg. 52 min. 42 seconds of Taurus; these Examples are sufficient for Direction, to find the Suns true Place at any time.

PROB. II. *The Suns distance from the next Equinoctial-Point; and his greatest Declination being given, to find the Declination of any Point required.*

Note, the Horizon needed not to have been delineated in this Problem, but the same Scheme refers to the Problems following, and therefore it was drawn.

With your Compasses take the Chord of 60 deg. upon the Centre C, describe the Circle H Z N O, and draw the Diameter H C O, which represents the Horizon, and at Right-Angles, or Perpendicular thereunto, draw Z C G, the Azimuth of East or West, and take the Latitude of the place, (which in this Example is 51 deg. $\frac{1}{2}$,) and prick it from O to N, and from H to S, and draw the Hour of six N C S; then prick from Z to Æ, and from N to Q 51 deg. $\frac{1}{2}$, and draw the Equinoctial Line Æ C Q; then the Suns place being given, take 23 deg. 31 min. and prick from Æ to ♋, and from Q to P and draw the prickt Line ♋ C P, then take the Suns distance from the next Equinoctial Point, which in this Example shall be 61 deg. 18 min. out of the Line of Sines, and prick it from C to ☉, and through ☉ draw a Parallel Line to the Equinoctial, as T D, and it shall be a Parallel of Declination, and where it cuts the outward Meridian, as at T, apply the distance Æ T to the Line of Chords, and you have the Declination 20 deg. 30 min. which was required; Or you may take the nearest distance from ☉ to the Equator, and apply it to the Line of Sines, and that will give you the Declination 20 deg. 30 min. and if through ☉ you draw a Line Parallel to the Horizon H O, as *e f*, it is a Parallel of the Suns Altitude. By the Logarithms in the Right-Angled Triangle C K ☉; in the Stereographick Projection we have given, first the Hypothenuse, C ☉ 61 deg. 18 min. secondly, the Angle K C ☉ 23 deg. 31 min. hence to find K ☉, as the Radius—10

Is in proportion to the Sine of the Suns Declination 23 *d.* 31 *min.* K C ☉ 960099

So is the Sine of the Suns distance from the next Equinoctial Point 61 *d.* 18 *m.* C ☉ 994307

To the Sine of his Declination required 20 *deg.* 30 *min.* K ☉ 954406

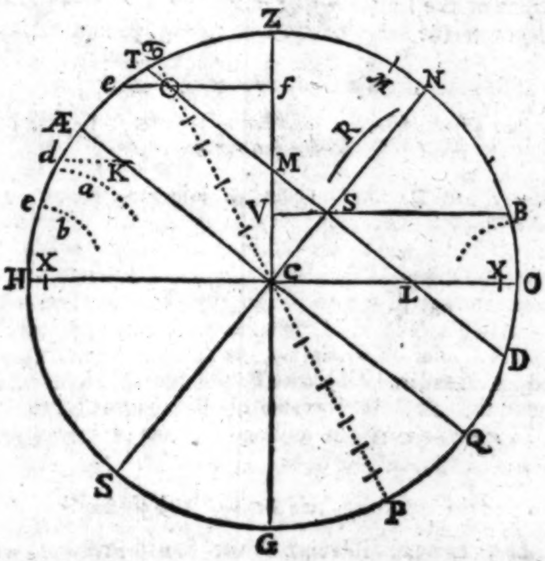
Extend the Compasses in the Line of Artificial Sines from 90 *deg.* to 23 *deg.* 30 *min.* the same extent will give the distance from the Suns place to his Declination.

The *Sun* being either in 1 *deg.* 18. *min.* of *Gemini*, or 29 *deg.* 42 *min.* of *Capricorn*, or 1 *deg.* 18 *min.* of *Sagittarius*, or 28 *deg.* 42 *min.* of *Cancer*; that is, 61 *deg.* 18 *min.* from the next Equinoctial Point; the Declination will be found to be 20 *deg.* 30 *min.*

PROB. 3. *Having the Suns greatest Declination, and his distance from the next Equinoctial Point; to find his Right Ascension.*

In the following Scheme, having drawn the Parallel of the Suns Declination TD, passing through the Suns place at ☉ the extent S ☉ is the Sine of the Suns Right Ascention, from

from the next nearest Equinoctial Point, to the Radius of the Parallel T D; and therefore place the extent ST from C to X, and upon X as at a Centre with the extent S ☉, describe the Arch at R, a Ruler laid from the Centre just touching the extremity of that Arch, finds the Point N in the Limb of the Meridian, and the Arch O N, applied to the Line of Chords, is 59 deg. ¼, and so much is the Suns Right Ascension in the first quarter of the Ecliptick. In the Triangle C K ☉ we have given as before, (1.) the Angle of the Suns greatest Declination K C ☉ 23 deg. 31 *min.* (2.) the Longitude of the Sun from the next Equinoctial Point *Aries* C ☉ 61 deg. 18 min. hence to find the Suns Right Ascension, the proportion.



As the Radius	10
to the Tangent of the distance 61 deg. 18 min. C ☉	1026162
So is the Co-sine of the Suns greatest Dec. 23 deg. 31 min. K C ☉	996234
to the Tangent of the Right Ascension C K 59 deg. 9 min.	1022396

Or extend the Compasses from Sine 90 deg. to Sine 66 deg. 29 min. the same distance will reach from the Tangent 61 deg. 18 min. to Tangent 59 deg. 9 min. which is the Suns Right Ascension in 1 deg. 18 min. of *Gemini*. But this you are to observe, that if the Right Ascension sought, be in the second Quadrant as in ♋ ♌ ♍, then you are to take the Complement of the Arch found to 180 deg. if in the third Quadrant, as in ♎ ♏ ♐, add 180 deg. to the Arch found; but in the last Quadrant, as in the last Quadrant, as in ♑ ♒ ♓, substract the Arch found from 360 deg. and you shall have the Right Ascension required.

Example 2. The Sun in 28 deg. 42 min. of ♋, that is 61 deg. 18 min. from the Equinoctial Point ♎; say as before. As the Radius is to the Co-sine of the greatest Declination, so is the Tangent of the *Suns* distance from the next Equinoctial Point 61 deg. 18 min. to the Tangent of 59 deg. 9 min. as before, which taken from 180, is 120 deg. 51 min. which is the *Suns* Right Ascension required.

Example 3. The *Sun* in 1 deg. 18 min. of ♐ that is 61 deg. 18 min. from the next Equinoctial Point ♎, the work is the same as before; therefore to the Arch found I add 180 *deg.* makes 239 deg. 9 min. the Right Ascension of the *Sun* sought.

Example 4. The *Sun* in 28 deg. 42 min. of ♑, 61 deg. 18 min. from the next Equinoctial Point ♈, the Operation is the same with the former Example; wherefore substract the Arch found 59 deg. 9 min. from 360 deg. and there will remain 300 deg. 51 min. which is the *Suns* Right Ascension required.

PROB. 4. *The Elevation of the Pole, and Declination of the Sun being given; to find the Ascensional Difference.*

This is represented in the Figure by S L in the Parallel of Declination, and it is therefore to be reduced into the common Radius, therefore take the Radius of the Parallel

rallel S T, and prick it from C to X, as before; then take the extent S L, and setting one Foot upon X, with the other draw the part of an Arch at *a*, lay a Ruler from C, that it may just touch the outside thereof, and it cuts the Circle in *d*, and take Chord or Extent H *d*; and you will find it 28 deg. which being converted into Time, is 1 hour 52 min, and so much doth the *Sun* rise before, and set after six in summer; but so much doth he rise after, and set before six in winter. In the right Angled spherical Triangle S L C are known. 1. S C L the Complement of the Poles Elevation 38 deg. 28 min. 2. The *Suns* Declination 20 deg. 30 min. hence to find the ascensional difference S K.

As the Radius is in Proportion —————— 10
to the Tangent of the Latitude 51 deg. 32 min. —————— 10.09888
So is the Tangent of the *Suns* Declination 20 deg. 30 min. L S —————— 9.57274

to the Sine of S K the ascensional difference 28 deg. 00 min. —————— 9.67162

PROB. 5. *The Suns Right Ascension, and his ascensional difference being given; to find his Oblique Ascension, and Descension.*

TO perform this, you must observe these two following Rules. 1. If the *Suns* Declination be *North*, you must substract the ascensional difference from the Right Ascension, and the remainder will be the Oblique Ascension; but if you add them together, the sum will be the Oblique Descension. 2. If his Declination be *South*, add the ascensional difference, and the Right Ascension together, the sum will be the Oblique Ascension; but if you substract it, the remainder will be the Oblique-Descension. Admit the *Sun* is in 1 deg. 18 min. of *Gemini* by the third Problem, his Right Ascension is 59 deg. 9 min. and his ascensional difference by the fourth Problem, is 28 deg. 00 min. therefore according to the first Rule, because his Declination is *North*, the difference 31 deg. 9 min. is the *Suns* Oblique-Ascension, and the sum of them 80 deg. 9 min. his Oblique-Descension.

PROB. 6. *To find the Sun-Rising, and Setting, with the length of the Day and Night.*

YOu must find the ascensional difference by the fourth Problem, which converted into Time, allowing 4 min. of an hour for every deg. and 4 seconds for every min. and the sum of hours and min. is his difference of Rising and Setting before or after the hour of six, which was found before to be 28 deg, or 1 hour 52 min. Therefore when the *Sun* is in Northern Signs, add the sum to six, and the total is the semi-diurnal Arch, as in this Example, is 7 hours 2 min. the time of *Sun*-setting, and substract it from 6, and the remain is 4 hours 8 min. the time of *Sun*-rising; double 7 hours 52 min. it is 15 hours 44 min. the length of the Day, substract it from 24 hours 00 min. and the remain is 8 hours 16 min. the length of the Night, in the Lat. of *Bristol* 51 deg. 28 min North.

PROB. 7. *The Elevation of the Pole, and Declination of the Sun being given; to find his Amplitude.*

MEasure the extent C L with the Compasses in the Line of Sines, and it will reach to 34 deg. 40 min. and so much doth the *Sun* rise and set to the Northward of the East and West in the Latitude of 51½ North, when his Declination is 20 deg. 30 min. North; but he riseth and setteth so much to the Southward of the East and West, when his Declination is much South.

In the Right Angled spherical Triangle L S C, having the Angle L C S, the Complement of the Latitude of 38 deg. 32 min. and L S the suns Declination 20 deg. 30 min. (in 1 deg. 18 min. of *Gemini*) his Amplitude by Calculation may be found thus.

As the Co-sine of the Latitude 51 deg. 28 min. L C S —————— 979447

is to the Radius 90 deg. —————— 10
So is the Sine of the Declination 20 deg. 30 min. L S —————— 954432

to the Sine of the Amplitude C L 34 deg. 12 min. —————— 974985

This is in common use for the finding of the Variation of the Compass at Sea, by comparing the Coast, or Amplitude of the *Sun*, observed by an Amplitude or Azimuth-Compass at the *Suns* rising or setting, and by his Amplitude (found by this proportion) the difference sheweth the Variation. *Example.*

Example. Admit you observed the Suns Amplitude of Sun rising, by your Compass described in the first Chapter and fifth Book of this Treatise.

By the Compass, the Magnetical Amplitude ——— 45 deg. 55 min. North-easterly.
By the Rules beforegoing find the true Amplitude, 34 deg. 40 min. North-easterly.
Subtract the less out of the greater, the difference 11 deg. 15 min. Variation.

And by reason the Magnetical Amplitude is farther from the North at Sun rising than the true Amplitude; therefore the Variation 11 *deg.* 15 *min.* (which is one Point) is Westerly; and if you are bound to a place that bears N. of you, you must sail N. by E. or if you bear West, you must sail West and by North; and if South, the Course must be South by West; or if you bear East, then the Course must be East by South; and so of all the rest of the Points you must allow in like manner. But admit the Magnetical Amplitude at Sun setting observed by the Compass were 23 *deg.* 25 *min.* from the west toward the North, and the true Amplitude found to be 34 deg. 40 min. the same way the difference is 11 deg. 15 min. and by reason the Magnetical Amplitude at Sun-set is farther from the North than the true Amplitude, the Variation is Easterly; and so the North Point of the Compass is the N by E, and N E is N E by E, and E is E by S, and South is S by W, and W is W by N.

PROB. 8. *Having the Latitude of the Place, and the Suns Declination, to find the time when the Sun cometh to be due East or West.*

IN the Parallel of Declination 20 deg. ½ northerly the hour from six is represented by S M, with that extent upon the Point X draw the Arch *b*, the Ruler laid from C to touch the said Arch, cuts the Circle at (*e*,) the distance O *e* applied to the Line of Chords sheweth 17 deg. ¼ min. it converted into Time is 1 h. 9 m. and so much after six in the Morning, and before six in the Afternoon, will the *Sun* be due East or West.

Suppose the Latitude 51 deg. 28 min. and Declination North 20 deg. 30 min. therefore in the Right-Angled Spherical Triangle Z *N M* are given (1) Z *N* the Complement of the Latitude 38 deg. 32 min. (2) N M the Complement of the Suns Declination 69 deg 30 min. Then I say,

As the Radius 90 is in proportion———————————10
To the Co-tangent of N M the Compl. of the Declination 69 d. 30 m.———957274
so is the Tangent of Z N Compl. of Latitude 38 deg. 32 min.———990112
To the Co-sine of ZNM 17 d. 19 m. which reduced is 1 h. 9 m. of time 947386

Which 1 h. 9 m. added to 6 h. is 7 h. 9 m. the time in the Morning the Sun will be due East; and if you subtract 1 h. 9 m. from 6 h. 00 m. and the Remain will be 4 h. 51 m. the time in the Afternoon the Sun will be due West.

PROB. 9. *The Elevation of the Pole, and the Declination of the Sun being given, to find the Suns Altitude being due East or West.*

TAke the extent C M on the Vertical-Circle, and apply it to the Line of Sines, and it will reach to 26 deg. ½, and so much is his Altitude sought in Summer; if the Suns Parallel of Declination T M doth not meet with the prime Vertical Circle C Z, the Sun cometh not to the East or West, as it hapneth in Countries betwixt the Tropicks.

In the former Diagram, the Suns Altitude when he is due East and West, is shewed by the Arch C M, wherefore in the Triangle C V M we have given (1) the Suns Declination V M 20 deg. 30 min. (2) the Angle of the Poles Elevation M C V 51 deg. 28 min: to find his Altitude C M; I say,

As the Sine of the Latitude 51 deg. 28 min. U C M———————989334
is to the Sine of the Declination 20 deg. 30 min. U M———————954432
So is the Radius 90 deg.———————————10
to the Sine of the Altitude 26 deg. 35 min. C M———————965098

PROB. 10. *The Elevation of the Pole, and Declination of the Sun being given, to find the Suns Altitude at the Hour of Six.*

TAke the nearest distance from S to the Horizon C L, and apply it to the Line of Sines sheweth the Altitude to be 16 deg. and so much is his Depression under the Horizon at six, when he hath South Declination 20 deg. 30 min. in Northern Latitudes.

In the Triangle Z *S N*, (1.) The Complement of the Latitude Z *N* 38 deg. 32 min. (2.) The Complement of the Suns Declination *N S* 69 deg. 30 min. to find the Hypothenuse Z S; therefore I say

As the Radius————————————————10
To the Co-sine of 69 deg. 30 min. *N S*————————954432
so is the Co-sine of 38 deg. 32 min. Z *N*————————989334
To the Co-sine Z S the Compl. of the Altitude 74 d. 6 m.————943766

Whose Compl. is 15 deg. 54 min. the Suns Altitude at the hour of six, when the Declination is 20 deg. 30 min. North, in the Latitude 51 deg. 28 min. Extend the Compasses from Sine 90 deg. to Sine 20 deg. 30 min. the same extent will reach from the Sine of the Latitude 51 deg. 28 min. to the Sine of 15 deg. 54 min.

PROB. 11. *Having the Latitude of the place, and the Declination of the Sun given, to find the Suns Azimuth at the hour of six.*

THis is represented by V Z in the Parallel of Altitude of the Sun V S B; prick V B from C to W, and from thence with the distance V S draw the Arch at *b*, and lay the Ruler from C just touching the said Arch, it cuts the Circle in Y; the distance H Y measured on the Chords sheweth the Azimuth to be 13 deg. and so much is the Sun to the Northwards of the East or West at the hour of six.

In the Right-Angled Spherical Triangle Z N S of the general Diagram, we have known first, Z N, the Complement of the Latitude 38 deg. 32 min. (2) *N* S the Complement of the Suns Declination 69 deg. 30 min. to find the Azimuth of hour of six, represented by the Angle *N* Z S, I say,

As the Radius————————————————10
to the Sine Compl. of the Latitude 38 deg. 32 min. Z *N*————979447
So is the Co-Tangent of N S 69 deg. 30 min.——————957274
to the Co-tangent of N Z S the Azimuth from the North 76 deg. 54 m. 936721

Or extend the Compasses from the Radius to the Co-sine of the Latitude, the same extent will reach from the Tangent of the Declination, to the Tangent of the Azimuth 13 deg. 6 min. from the East or West Northerly.

PROB. 12. *The Latitude of the Place, the Suns Declination and the time from Noon being given, to find the Suns Altitude.*

IN the Latitude 51 deg. 28 min. *North*, the *Suns* Declination 23 deg. 31 min. *North* or *South*, to find the *Suns* Altitude at any hour.

By the Orthographick Projection.

The the Chord of 60 deg. and describe the Arch H T P, draw the Horizontal Line H C O, and from O to P prick off the Chord of the Latitude 51 deg. 28 min. and from P and S to T and D, set off the Chord of the *Suns* greatest Declination, 66 deg. 29 min. and draw the Parallels of Declination ♋ D and *d* ♑, and P C S the hour of six; then draw T C, which is the Ecliptick Line, and take off the Line of Sines, and prick down

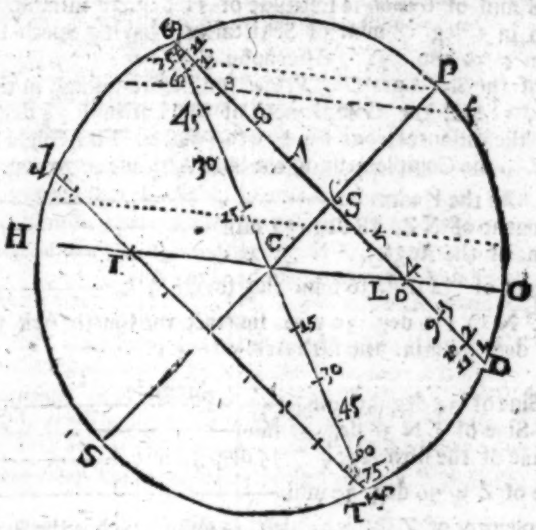
15 } 1 }
30 } deg. 2 }
45 } for the 3 } from 6 before it, and after it upon the Ecliptick
60 } Hours 4 }
75 } 5 }

Then take the nearest distance from 15 deg. to C S, the hour of Six, or *Axis*, and prick it from S to 5 and 7; and likewise take the nearest distance from 30 to C S, and lay it from S to 8 and 4; and in like manner do with the rest, then will the nearest distance from 4, 5, 6, 7, 8, 9, 10, 11, to the Horizontal Line H C O be the Sines of their respective Altitude;

so the Altitude for the hours 4, 5, 6 } In the Summer will be { 1 deg. 34 min. ; 9 30 ; 18 12

And so much is the *Suns* Depression under the Horizon at the hours of 8, 7 and 6 in Winter.

The



The Summer Altitude for the hours of	7, 8, 9, 10, 11	are	27 : 23, 36 : 42, 45 : 42, 53 : 45, 59 : 42		The Winter Altitude for the hours of	9, 10, 11	are	5 d. : 13, 10 : 28, 13 : 48

Example 2. Admit the Latitude were 51 deg. 28 min. and his Declination 00 d. 00 m. and the time from Noon is 2 hours 44 min. or 41 deg. 00 min. and the *Sun* being upon the Equinoctial.

In the Stereographick Projection beforegoing, in the Triangle Z Æ K, we have given first Æ Z the distance from the Zenith to the Equator, equal to the Latitude of the Place, 51 deg. 28 min. Secondly, Æ K the *Suns* distance from the Meridian 41 deg. to find Z K the Complement of the *Suns* Altitude.

The Operation by the Logarithms.

As the Radius 90 deg.——10
is to the Co-sine of the *Suns* distance from the Merid. 41 deg. 0 min. Æ K——987778
So is the Co-sine of the distance from the Equat. to the Zen. 51 d. 28 m. Æ Z—979447
to the Co-sine of Z K 61 deg. 58 min——967225
Whose Complement to 90 deg. is the Altitude 28 deg. 2 min. which was required.

Example. Let it be required to find the *Suns* Altitnde at 10 a Clock and 2 min. before Noon, when the *Sun* is in 1 deg. 18 min. of *Gemini* the Declination being 20 deg, 30 m. northerly in the Latitude 51 deg. 28 min. north.

In the Scheme of the Stereographick Project. foregoing in the Triangle N Z ☉, we have known, (1.) Z N the Complement of the Latitude 38 deg. 32 min. (2.) N ☉, the Complement of the *Suns* Delination 69 deg. 30 min. (3.) the comprehended Angle Z N ☉, the distance of the *Sun* from the Meridian 29 deg. 30 min. to find Z ☉, and hereby the *Suns* Altitude 92 ☉, I say,

As the Radius 90——10
is to the Co-Tangent of the Latitude 51 deg. 28 min. N Z——990112
So is the Co-sine of the Angle from the Meridian 29 deg 30 min. Z N ☉——993962
to the Tangent of the fourth Ark 34 deg, 43 min,——984074

From the Complement of the *Suns* Declination 69 deg. 30 min. substract 34 deg. 43 min. there remains 34 deg. 47 min. the fifth Ark.

Co. Arith.

As the Co-sine of the fourth Ark 34 deg. 43 min.——008514
is to the Co-sine of the Latitude 38 deg. 32 min. Z N——989334
So the Co-sine of the fifth Ark 34 deg 47 min.——991451
to the Co-sine of Z ☉ 38 deg. 36 min.——1989299

Whose

Whose Complement to 90 deg. is 51 deg. 24 min. the *Suns* Altitude above the Horizon being in 1 deg. 18 min. of *Gemini* in Latitude of 51 deg. 28 min. north.

Suppose the Sun in 1 deg. 18 min. of Sagittarius, having South-Declination 20 deg. 30 min. and the h. 1 59 min. 52″, Afternoon.

In the Scheme of the Stereographick Projection before-going, in the Oblique-Angled Triangle Z N ⊙, 1. NZ the Complement of the Latitude 38 deg. 32 min. 2. N ⊙, 110 deg. 30 min. the distance from the North-Pole, 3. The Angle Z N ⊙ 29 deg. 58 min. to find the Z ⊙ the Complement of the Suns Altitude to 90 deg.

The Operation. As the Radius 90 ——— 10
is to the Tangent of NZ, 38 deg. 32 min. ——— 990112
So is the Co-sine of the Angle, Z N ⊙, 29 deg. 58 min. ——— 993768
to the Tangent of 34 deg. 36 min. the fourth Ark, ——— 983880

From the Ark N ⊙ 110 deg. 30 min. subtract the fourth Ark 34 deg. 36 min. and there remains 75 deg. 54 min. the fifth Ark.

Co-Arith.
As to the Co-Sine of 34 deg. 36 min. ——— 008453
is to the Co-Sine of Z N 38 deg. 32 min. ——— 989334
So is the Co-Sine of the fifth Ark *q* ⊙ 75 deg. 54 min. ——— 938670
to the Co-Sine of Z ⊙ 76 deg. 37 min. ——— 936457

Now the Complement of Z ⊙, is 13 deg. 23 min. which is the Suns Altitude required.

PROB. 13. *The Suns Altitude, the time from Noon, and the Declination being given; to find his Azimuth.*

See the Scheme of the Stereographick Projection before going.

Examp. 1. The *Suns* Altitude 51 deg. 12 min. the time 9 ho. 49 min. 52 seconds in the Forenoon, and the *Suns* Declination 20 deg. 30 min. north, to find his Azimuth.

In the Oblique spherical Triangle Z N ⊙, we have known. 1. Z ⊙ the Complement of the *Suns* Altitude 38 deg. 48 min. 2. The Angle Z N ⊙ 29 deg. 58 min. the *Suns* distance from the Meridian. 3 The Complement of the *Suns* Declination N ⊙ 69 d. 30 m.

Operation. *Co. Arith.*
As the Co-sine of the Altitude 38 deg. 48 min. Z ⊙ ——— 020301
is to the sine of the Angle from the Merid. 29 deg. 58 min. Z N ⊙ ——— 969853
So is the Co-sine of the Declination 69 deg. 30 min. N ⊙ ——— 997159
to the Sine of the *Suns* Azimuth N Z ⊙ 13 deg. 42 min. ——— x987313

The Azimuth from the North. Example 2.

Now admit the Altitude were 13 deg. 23 min. the time 1 hour 59 min. 52 sec. after noon, and his Declination south 20 deg. 30 min.

In the general Diagram of the *Stereographick Projection* you have in the Oblique-Angled spherical Triangle Z N ⊙, 1 Z ⊙ the Complement of the *Suns* Altitude 76 deg. 37 min. 2. The Angle Z N ⊙ 29 deg. 58 min. his distance in time from the Meridian. 3. N ⊙ 110 deg. 30 min. the distance of the *Sun* from the north Pole.

To find the Angle N Z ⊙ the Suns Azimuth from the North.

The Operation. *Co. Arith.*
As the Co-Sine of the Altitude Z ⊙ 76 deg. 37 min. ——— 001196
is to the Sine of the Angle from the Merid. Z N ⊙ 29 deg. 58 min. ——— 969853
So is the Co-Sine of the Polar distance N ⊙ 110 deg. 30 min. ——— 997159
to the Sine of the Suns Azimuth N Z ⊙ 151 deg. 16 min. ——— x968208

PROB. 14. *The Latitude of the place, the Suns Declination and his Altitude being given, to find the Suns Azimuth.*

Example. 1. In the Latitude 51 deg. 28 min. N. the Suns Declination being 20 deg. 30 min. N. and his Altitude 51 deg. 12 min. to find the Suns Azimuth.

In the former Diagram, in the Oblique-angled Triangle Z ⊙ N, there are given the three Sides, Z N 38 deg. 32 min. the Complement of the Latitude, N ⊙ 69 deg. 30 min. the Complement of the Declination, and Z ⊙ 38 deg. 48 min. the Complement of the Altitude, to find the Angle N Z ⊙, the Suns Azimuth from the North.

The

The Operation by the Logarithms.

The containing Sides { Z N 38 deg. 32 min. Co-Arith. Sine		0.20553
Z ⊙ 38 deg. 48 min. Co-Arith. Sine		0.20301
The opposite side N ⊙ 69 deg. 30 min. half Sum, 73 d. 25 m. Log. Sine		9.98155
The Sum of the 3 sides 146 d. 50 m. Remain. or Dif. 3 d. 55 m. Log. Sine		8.83445
The half Sum 73 d. 25 m.	Sum of the 4 Logarithms	19.22454
The Diff. of the opposite side from the half Sum, called the Remainder, 3 deg. 55 min. is	C. 65 d. 50 m. half Sum	9.61227
	65 d. 50 m. which doubled	
	131 deg. 40 min. the Suns Azimuth from the North.	

Whose Complement to 180 d. 48 m. is the Azimuth from the South.

Example. 2. In the Latitude 51 d. 28 m. North, the Suns Declination being 20 d. 30 m. South, and his Altitude 13 d. 23 m. to find the *Suns* Azimuth.

In the former Diagram, in the Oblique Triangle Z ⊙ N (where the Declination is Southerly) there is given the three sides, N Z 38 deg. 32 m. the Complement of the Latitude, Z ⊙ 76 deg. 37 min. the Complement of the Altitude, and N ⊙ 110 deg. 30 min. the *Suns* distance from the north Pole, to find the Angle N Z ⊙, the *Suns* Azimuth from the north.

The Operation by the Logarithms.

The containing Sides { Z N 38 deg. 32 min. Co-Arith. Sine		0.20553
Z ⊙ 76 deg. 37 min. Co-Arith. Sine		0.01196
The opposite side N ⊙ 110 d. 30 m. half sum 112 d. 49 m. Log. Sine		9.96461
The sum of the 3 sides 225 d. 39 m. Remain. 2 deg. 19 m. Log. Sine		8.60662
The half sum, 112 d. 49 m.	Sum of the 4 Logarith.	18.78872
The Remaind. opposite side being subtracted from the half sum 2 d. 19 m.	The half sum, which is Sc. 75 d. 39 m.	9.39436
	which doubled 75 d. 39 m.	
	is the Suns Azimuth 151 d. 18 m. from the North.	

Whose Complement (to 180 d.) 28 d. 42 m. is the Azimuth from the South.

By the *Suns* Azimuth and the Magnetical Azimuth, you may find the Variation of the Compass.

Example. Admit the Magnetical Azimuth in the Afternoon is —— S. 59 d. 33 m. West.
And the *Suns* Azimuth is —— S. 48 d. 18 m. West.

The difference is the Variation —— 11 d. 15 m.

And the Magnetical Azimuth being nearer to the North than the true Azimuth by 11 deg. 15 min. (which is one Point of the Compass) shews the Variation to be one Point Westerly.

And suppose the Course by the Compass be East, the true Course is East by North.

Mr. *Boroughs* observed in the Year 1580, the Variation 11 d. 15 m. Easterly in *Lime-House-Fields* near *London.*	The Magnetical Rumb	90 d. 00 m.
	Subtract the Variation Westerly	11 d. 15 m.
	there remains the true Rumb N E	78 d. 45 m.

Mr. *Gunter* in the Year 1622 in the same place found the Variation 6 deg. 15 min. East.

Examp. 2. Suppose the Magnetical Azimuth be —— S. 37 d. 03 m. West.
And the Suns Azimuth be —— S. 48 d. 18 m. West.

Subtract the lesser out of the greater, the difference —— 11 d. 15 m.

And in regard the Magnetical Azimuth is farther from the North than the true Azimuth by 11 deg. 15 min. therefore the Variation is Easterly one Point, and consequently all the Points stand 11 deg. 15 min. or one Point to the right hand of their true Places; and therefore, to make good a North Course, you must sail by your Compass N by W; and an East Course, sail E by N, and a South Course, sail S by E; and to make good a West Course, sail W by S; and so it is to be understood of all other Courses.

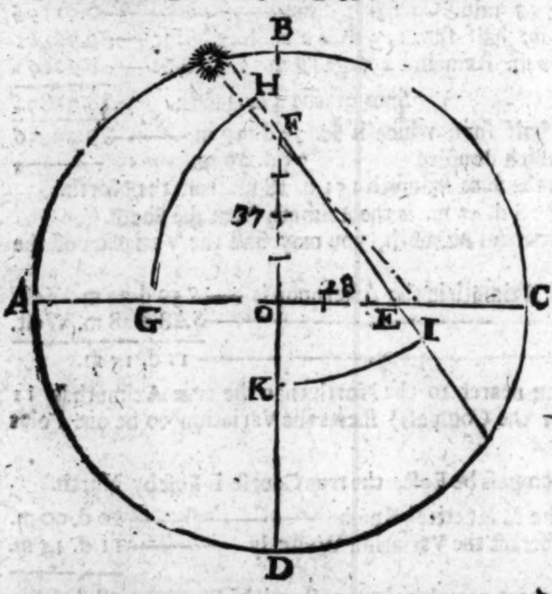
The Year 1666 at *Bristol*, in *Rownam* Meadows, Mr. *Philip Stainard*, my self, and some other Friends, Masters of Ships, took with us a Quadrant (described in the fifteenth Chapter of the Second Book) of 20 Inches Semidiameter, and one Needle, and one Azimuth Compass, (described in the first of the Fifth Book) the Needle about nine Inches long, and in the Afternoon we made these Observations following.

Suns Altitude.		Magnetic. Azimuth.		Suns Azimuth.		Variation westerly.	
Gr.	M.	Gr.	M.	Gr.	M.	Gr.	M.
44	20	72	00	70	38	01	22
39	30	80	00	78	24	01	36
31	50	90	00	88	26	1	34
27	42	95	00	93	36	1	24
23	20	103	00	101	23	1	37

PROB. 15. *To find the Altitude of the Sun by the shadow of a Gnomon set Perpendicular to the Horizon by the Scale; also by Trigonometry.*

WIth your Compasses on a piece of Board, describe the Circle A B C D, place it Horizontal with a Gnomon Perpendicular thereto, in the Centre O cross it with two Diameters at right Angles; then turn the Board, until the shadow be upon one of the Diameters, and at the end of the shadow make a Mark, as here at E; lay down also the length of the Gnomon from the Centre on the other Diameter from O to F, draw a right Line from E to F, as E F H; then with the Chord of 60 deg. sweep the Arch G H upon E as a Centre; apply the distance G H on the Arch to your Line of Chords, and that will give you the Altitude of the Sun required, which in this Example is 53 deg.

Operation. As the parts of the shadow 28 ——— 144716
are to the parts of the Gnomon 37 ——— 156820
So is the Radius ——— 1000000
to the Tangent of 52 deg. 53 min. ——— 1012104



So the Pin or Gnomon O F being 37 equal parts, and the shadow O E 28 such parts, the Altitude is found 52 deg. 53 min. or the Gnomon being 28, and the shadow 37 parts, the Altitude will be 37 deg. 07 min. or the shadow being 83, the Gnomon or Staff 100, the Angle will be 50 deg. 18 min. the Altitude of the upper edg of the Sun or Angle H E G; from which, taking the Semi-diameter of the Sun 16 min. there remains 50 deg. 2 min. the Altitude of the Centre of the Sun. After this manner, if you observe the greatest Meridian-Altitude of the Sun the 11th of *June*, and 10th of *December*, you shall by the difference of them find the distance of the Tropicks; the greatest Declination of the Sun, the Elevation of the Equator, or the Latitude of the Place.

Example at *London*. Suppose the Suns Merid. Alt. taken *June* 11. 1676	61 d. 59 : 30.''
The Suns least Meridian-Altitude taken *December* 10	14 : 56 : 30
The diff. is the distance of the Trop. of which take the half	47 : 03 : 00
Which is the Suns greatest Dec. subtract from the greatest Alt.	23 : 31 : 30
Leaves the Elevation of the Equator,	38 : 28 : 0
Whose Complement is the Latitude of the Place.	51 : 32 : 0

PROB. 16. *Having the Latitude of the Place, the Suns Declination, and the Suns Altitude, to find the hour of the day.*

THe Rule by the Logarithms is thus; Add the Complement of the *Suns* Altitude, and the Complement of the *Suns* Declination, (for distance of the *Sun* from the Elevated Pole) and the Complement of your Latitude together, and from half the sum thereof subtract the Complement of the Altitude, and note the difference. Thus in our Latitude of *Bristol* 51 deg. 28 min. the Declination of the *Sun*, being 20 deg. 30 min northward, and the Altitude 51 deg. 12 min. I find the hour from the Meridian, as follows.

Altitude of the *Sun* 51 d. 12 m. the Compl. 38 d. 48 as the Radius ——— 10
Declination north 20 : 30

The

The dist. from the Pole	69 : 30	to Sine of the Polar distance	997159
Latitude north 51 : 28. Compl.	38 : 32	so is the Sine Compl. of Lat.	979447
The sum of all three	146 : 50	to a fourth Sine	976606
The half sum	73 : 25	As the 4 sine is to the sine of half sum	908155
The difference	34 : 37	so is the sine of the diff.	975441
			1883596
To a seventh Sine, to which add the Radius			1906990
And take the half			998495
Which is the Sine Compl. of	15 d. 0 m.		
Which doubled is	30 d. 0 m. or 2 hours from noon.		

PROB. 17. *Having the Azimuth of the Sun, the Altitude of the Declination; to find the hour of the Day.*

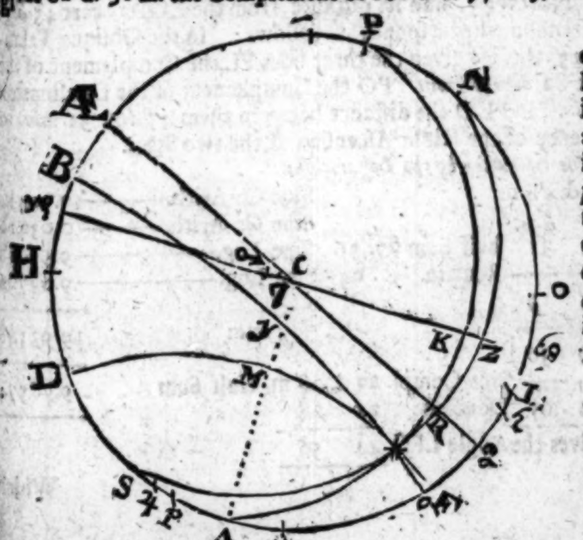
THe Declination 20 deg. 30 min. north, the Altitude 51 deg. 12 min. the Azimuth from the north 131 deg. 42 min. to find the hour from Noon.

Operation.	As the Co-sine of the Declination 69 deg. 30 min.	997159
	is to the Sine of the Azimuth 131 deg, 42 min.	987311
	So is the Co-sine of the Altitude 38 deg. 48 min.	979699
	to the Sine of the hour 29 deg. 58 min	1967010
	Which is 1 hour 59 min. 52 seconds	969851

PROB. 18. *How to find the Right Ascension, and the Declination of a Star, having the Longitude and Latitude thereof.*

THe Mouth of *Sirius*, whose Longitude is 9 deg. 32 min, 69 seconds, Latitude 39 deg. 30 min. south, to find the Right Ascension and Declination.

To Project the Sphere *Stereographically*, draw the Meridian with a Chord of 60 deg. you may mark the Horizon H O, and Vertical Z N; then set the Latitude 51 deg. 28 min. from O to N, from H to S, and from N to Q, and from Z to Æ; and draw the Equinoctial Line Æ C Q, then take the distance of the Pole of the Ecliptick, from the Pole of the World 23 deg. 31 min. and prick it from N P, from Æ to *Capricorn*, from S to A, and from Q to *Cancer*; then draw the Ecliptick Line ♑, C, *Cancer*, on which you must put the Longitude or distance of the Star, from the next Equinoctial Point, as in this Example; the Star in the Mouth of the great Dog or *Sirius*, his Longitude is 9 deg. 32 min. of *Cancer*, and his Latitude is 39 deg. 30 min south, take 9 deg. 32 min. out of 90 deg. the remain is 80 deg. 28 min. the distance of the Star from the next Equinoctial Point C, prick that from C to K on the Ecliptick, and draw the Circle of Longitude PK S, then prick the Latitude 39 deg. 30 min. from *Capricorn* to D, and from *Cancer* to F from the Chords; then take the same from the half Tangents, and prick it from C to M, and draw the Circle of Latitude of the Star Parallel to the Ecliptick, as D M F, and where this Parallel cuts the Circle of Longitude, as at *Sextile*, that is the place of the Star; then draw the Meridian Circle from the north Pole through *Sextile* to the south Pole, and it cuts the Equinoctial in R; measure C R on the Line of half Tangents, and it gives 82 d. 31 m. the Complement to 180 d. is 97 d. 39 m. the Right Ascension desired.



Now to find the Declination of the Star; lay a Ruler over P and the Ecliptick at K, and it will cut the Arch in L, take a Chord of 90 deg. and prick it from L to *p*, lay a Ruler over *p* and P, and it will cut the Ecliptick in *Mars*; lay the Ruler over *Mars*, and *Sextile*, and it cuts the Limb in *e*; measure Q *e* on the Line of Chords, and it is 16 deg. 14 min. the Stars Declination required.

Operation. Take 9 deg. 32 m. the Longitude of the Star, out of 90 deg. there remains 80 d. 28 m. his distance from the next Equinoctial Point; which being known, the first Operation is,

As

As Radius —————————— 10
is to the Sine of the Stars Longit. from the next Equinoctal Point 80 d. 28 m.— 999396
So is the Co-Tangent of the Stars Latitude 39 deg. 30 min —————— 1008389
to the Tangent of the fourth Ark 50 deg. 6 min —————— 1007785

Compare this fourth Ark with the distance betwixt the Poles of the Ecliptick, and the Poles of the World 23 deg. 31 min. if the Longitude and Latitude of the Star be alike, as in the north Signs, ♈ ♉ ♊ ♋ ♌ ♍, and the Latitude on the north side the Ecliptick; or if the Longitude be among the Southern Signs, as ♎ ♏ ♐ ♑ ♒ ♓, and the Latitude southward; then shall the difference between the fourth Ark found, and the distance of the Poles be your fifth Ark. But if the Longitude and Latitude shall be unlike, as it is in this Example; the Longitude in a northern Sign, and the Latitude south; or the Longitude in a southern Sign, and the Latitude north, then add this fourth Ark found, to the distance of both Poles 23 d. 31 m. the sum of both shall be the fifth Ark.

Then say, as the Sign of the fourth Ark 50 deg. 6 min. —————— 988489
is to the Sine of the fifth Ark 73 deg. 37 min. —————— 998200
So is the Tang. of the Stars Long. from the next Equin. Point 80 d. 28 m.—— 2077484
to the Tang. of the Stars Right ascen. from the next Eq. Point 82 d. 21 m.— 2075684
Which subtract from 180 leaves *97* d. *39* m. the Right as. of *Sirius* required — 1087195

To find the Declination,

As the Co-sine of the fourth Ark 50 deg. 6 min. —————— 980716
is to the Co-sine of the fifth Ark 73 deg. 37 min. —————— 945034
So is the Sine of the Stars Latitude 39 deg. 30 min. —————— 980351
1925385
to the Sine of the Stars Decl. required 16 deg. 14 min. —————— 944669

PROB. 19. *The Latitude of the place, the Meridian Altitude of an unknown Star, and the distance thereof from a known Star being given, to find the unknown Stars Right Ascension and Declination.*

First, by the unknown Stars Meridian Altitude, you may find his Declination, by the following Directions. If the Star Culminate upon the South part of the Meridian in North Latitude, or upon the North part of the Meridian in South Latitude, subtract the Complement of the Latitude of the place, from the Stars Meridian Altitude, the Remainder is the Stars Declination, Northerly in North Latitude, and Southerly in South; but if the Complement of the Latitude exceed the Meridian Altitude, subtract the Meridian Altitude from the Complement of the Latitude, the Remainder is the Stars Declination, Southerly in North Latitude, and Northerly in South: But if the Star Culminate upon the North Part of the Meridian in North Latitude, or upon the South part of the Meridian in South Latitude, above the Elevated Pole, then subtract the Meridian Altitude from 180 deg. and from the Remainer subtract the Complement of the Latitude, the last Remainer is Declination, Northerly in North Latitude, and Southerly in South; but if the Star Culminate under the Elevated Pole; to the Meridian Altitude add the Complement of the Latitude, the sum is the Declination, Northerly in N. Latitude, and Southerly in S.

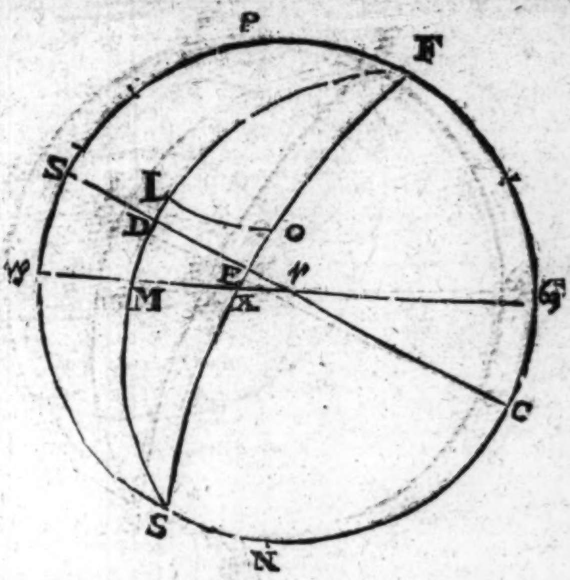
Exam. 1577. Noble *Tycho Brahe* found the Declination of the northern Star in the breast of *Pegasus* to be 22 *deg.* 26 *min.* Northerly, and its distance from the Eagles heart 45 *deg.* 31 *min.* whereby the right Ascension may be found, as follows: In the Oblique Triangle FOL in the following Scheme, there is given the three sides FL the Complement of the Declination of the Eagles heart 82 *deg.* 08 *min.* FO the Complement of the Declination of *Pegasus* breast 67 *deg.* 34 *min.* and LO the distance between them 45 *deg.* 31 *min.* to find the Angle LFO, the difference of the Right Ascension of the two Stars.

The Operation by the Logarithms.

The containing sides {	FL	82 d.	08 m.		Sine Co-Arith.	0.00411
	FO	67	34		Sine Co-Arith.	0.03418
The opposite side	LO	45	31	half Sum 97. 36	Sine Log.	9.99618
				Remain. 52. 05	Sine Log.	9.89702
Sum of the three sides		195	13			
					Sum	19.93148
The half sum		97	36			
				Sine Compl. 22 d. 28 m.	Half Sum	9.96574
The Remainer		52	05	Doubled 22 28		
				Gives the Angle LFO 44 56		

Which

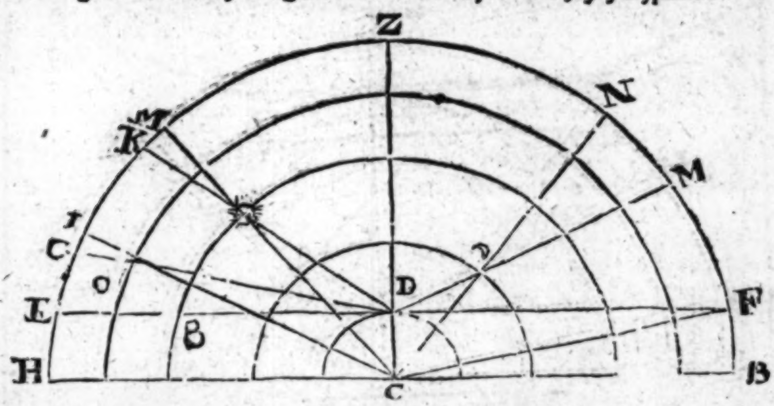
Which is the difference of the Right Ascension of the two Stars, and added to the Right Ascension of the Eagles heart 292 deg. 35 min. the sum 337 deg. 31 min. is the Right Ascension of the Star in *Pegasus* breast, which was required.



Of the Parallax of Altitude of the Sun, Moon, or Stars.

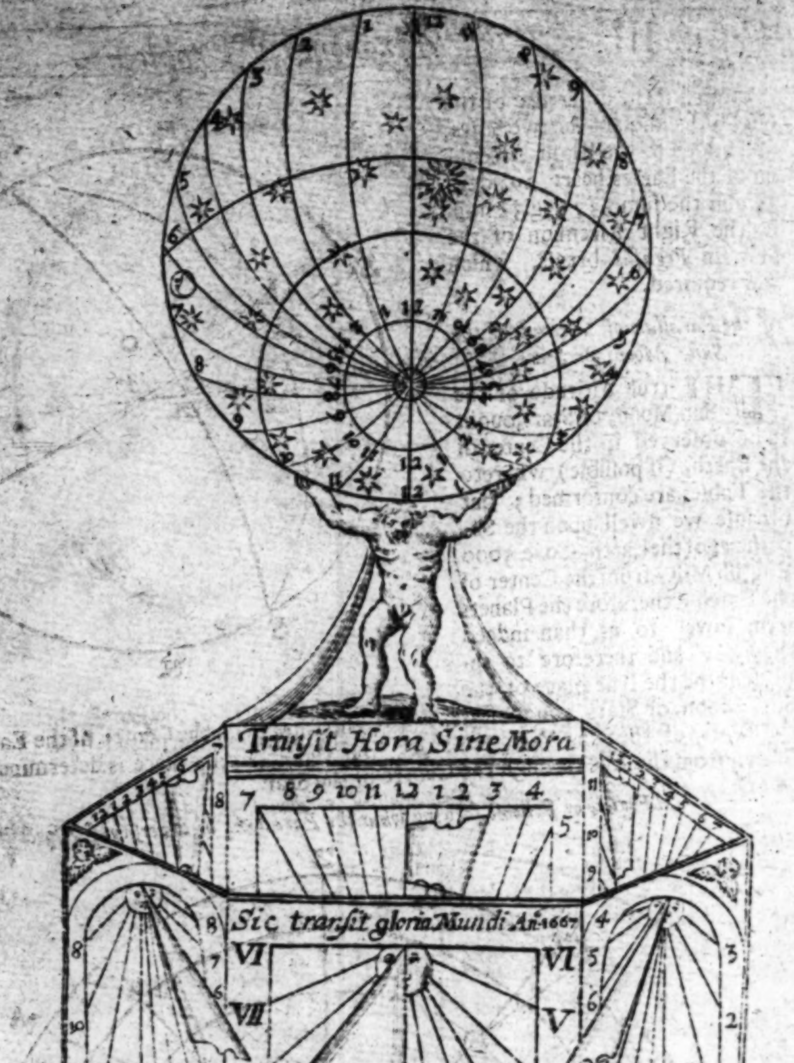
THE true Altitude of the Sun, Moon, or Stars, ought to be observed in the Center of the Earth, (if possible) whereto the Tables are conformed; but because we dwell upon the Superficies of the Earth, above 5000 English Miles from the Center of the Earth; therefore the Planets seem lower to us than indeed they be; and therefore to represent the the true place of the Sun, Moon, or Stars, you must draw a Right-Line from the Centre of the Earth, through the Centre of the Sun, Moon, or Star; but the apparent place is determined by a Line drawn from the Eye through the Centre of the Star.

A Figure or Scheme shewing what the Parallax, or diversity of Aspect is.



In this Figure C denotes the Centre of the Earth.
D the Place or Superficies of the Earth, from whence the Sun, Moon, or Star is seen.
☾ ☉ and ♂, their Place in their Orbs.
C ♂ I, C ☉ M, C ☾ N, the Lines of their true Place.
D ♂ G, D ☉ K, D ☾ M, the Lines of their visible or apparent Places.
Hence the Angle made by the Intersection of the said two Lines through the Body of the Planet, is the Angle of Parallax, that is to say, in ♂ the Angle C ♂ D, which is equal to the Angle I ♂ G, in the ☉ the Angle of Parallax, is the Angle C ☉ D; and lastly, in the Moon it is the Angle C ☾ D, or N ☾ M. By this it is manifest, the nearer a Star is to the Centre of the Earth, and the lesser the Altitude above the Horizon, the greater is the Parallax; and hence it is, that the Orbit of the Moon being nearest to the Earth, her Parallax is greatest, and most perceptible, because the Semidiameter of the Earth bears a sensible proportion to the Semidiameter of the Moons Orbit, though it be very little, or nothing at all in comparison of the Orbs of ♄ ♃, and the fixed Stars, which is caused by the vast distance which is between them.

The End of the Sixth Book.



Horologium vitæ.

Latus ad occasum nunquam rediturus ad ortum
Vivo hodie, moriar cras, heri natus eram

The Art of Dialling.

Book. VII.

The Fundamental Diagram of the Dialling-Scale.

THe Diagram of the Gnomical Scale I have deſcribed, *Book* 2. *Chap.* 3. to which I refer you. I ſhall only enumerate the Lines on the Scale. There are ſix Lines on this Inſtrument. 1. A Line of Chords. 2. The Gnomon Line, or Line of Latitudes. 3. A Line of ſix Hours, for drawing the Hour-lines in any Dial, divided into every 10 Minutes. 4. A Line of the Inclination of Meridians. 5, and 6. Two Lines for the inlarging the Hour-lines: The greater is marked with +; the leſſer is marked with ——, called the greater and leſſer Pole for diſtinction-ſake, and theſe Lines are divided into every 10 Minutes.

Reader, read this; for I dare this defend,
Thy poſting Life on Dials doth depend.
Conſider thou, how quick the Hour's gone;
Alive to Day, to Morrow Life is done.
Then uſe thy Time, and always bear in Mind,
Time's Forehead hairy is, but bald behind.
Here's that which will decline to thee, and ſhow
How quick Time runs, how faſt thy Life doth go.
Yet be ingenious, learn the Practick Part,
And ſo attain to Practice of this Art:
Whereby you ſhall be able for to trace
Out ſuch a Path, where Sol *ſhall run his Race;*
And make the greater Coſumus *to appear,*
According to each Seaſon of the Year.

Of the kinds of Dials.

ALthough Gnomoniques pertain to Aſtronomy, yet I think it not amiſs for the eaſe of the Reader to place theſe in a diſtinct Book by themſelves.

Sun-Dials may be reduced to two ſorts. Some ſhew the Hour by the Altitude of the Sun, as Quadrants, Rings, Cylinders; and for the making thereof, you muſt know the Suns Altitude for any hour and quarter for every Day, or at leaſt every Tenth Day of the Year.

The other ſort ſhew the hour by the ſhadow of a Gnomon or Stile-Parallel to the Axis of the World, and of thoſe I treat chiefly in this Book. Theſe be all Projections of the Sphere, upon a Plane which lies Parallel to ſome Horizon on the Earth; and if upon ſuch a Plane the Meridians be projected, they ſhall ſuffice to ſhew the hour, without projecting the other Circles, as the Ecliptick, the Æquator with his Parallels of Declination, the Horizon with his Almicanters and Azimuths, which are ſometimes drawn upon Dials more for Ornament than Neceſſity.

Theorems premiſed.

FOR the better underſtanding the Art of Dialling theſe Theorems ſhould be known.

1. That every Plane whereupon any Dial is drawn, is part of the Plane of a great Circle of the Sphere, which Circle is a Horizon to ſome Countrey or other; That the Center of the Dial, repreſenteth the Center of the Earth, and the Gnomon which caſteth the Shade, repreſenteth the Axis, and ought to point directly to the two Poles.

2. That theſe Dial-Planes are not preciſely in the very Planes of great Circles; for then they would have their Centers in the Center of the Earth, from which they are removed almoſt 4000 Miles; and yet we may ſay they lie in the Planes of thoſe Circles, becauſe the Semidiameter of the Earth beareth ſo ſmall proportion to the Suns diſtance therefrom, that the whole Earth may be taken for one Point or Center, without any ſenſible Error.

3. That

3. That as all great Circles of the Sphere, so every Dial-Plane hath his Axis, which is a straight Line passing through the Center of the Plane, and making Right Angles with it; and in the Axis are the two Poles of the Plane, whereof that above our Horizon is called the Pole Zenith, and the other the Pole Nadir of the Dial.

4. That every Plane hath two Faces or Sides: And look what respect or situation the the North Pole of the World hath to the one side, the same hath the South Pole to the other; and these two sides will receive all the Hours of the longest Day: So that what one Side wanteth, the other Side shall have; and the one is described in all things as the other.

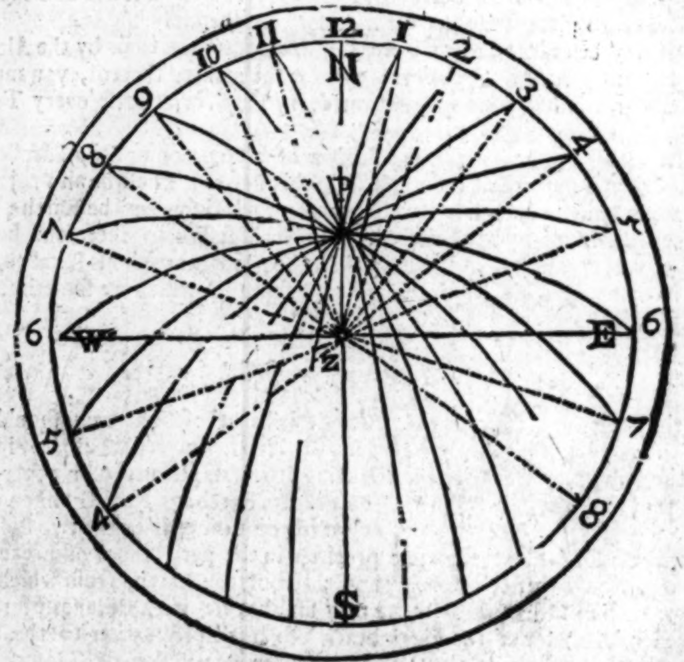
5. That as Horizons, so Dial-Planes are with respect to the Æquator divided into first, Parallel, secondly, Right; thirdly, Oblique Planes.

6. A Parallel or Polar-Plane maketh no Angles with the Æquator, but is either one and the same Plane with it, or equidistant to it: that is, the Gnomon stands bolt upright on the Plane at Right Angles, as the Axis of the World upon the Plane of the Æquator; because the Axis and Poles of the Dial are here all one with the Axis and Poles of the World, and the Hour-lines here meet all at the Center, making equal Angles, and dividing the Dial Circle into 24 equal parts, as the Meridians do the Æquator.

7. A Right Horizon or Dial-Plane cutteth the Æquator at Right Angles, and so passeth through the Poles of the World, whose Gnomon is parallel to the Plane thereof, and so the Hour-lines parallel one to another; because infinitely extended will never approach each other: Yet have those Dials a Center, though not from the meeting of the Hour-lines, but that through which the Axis of the Dial-Circle passeth, cutting the Plane at Right Angles.

8. An Oblique Horizon or Dial Plane cutteth the Æquator at Oblique Angles; and hath for its Gnomon the side of a Triangle, whose Angles vary according to the more or less Obliquity of the said Horizon: and the Gnomon shall always make an Angle with the Plane, of so many Degrees as the Axis of the World maketh with the Plane, or as either of the Poles of the World is elevated above the Plane.

9. Every Oblique Horizon is divided by the Meridians or Hour-circles of the Sphere into 24 unequal parts; which parts are always lesser, as they are nearer to the Meridian of that Horizon or Plane; and greater, as they are farther off: and on both sides of the Meridian of the Plane, the Hour-circles which are equally distant in time, and also equally in space. Whence it is, that the divisions of one Quadrant of your Dial-Plane being known, the divisions of the whole Circle are likewise known.



10. The

10 The Hour-lines in an Oblique-Dial, are the Sections of the Planes of the Hour-Circles of the Sphere, with the Dial-Plane: And because the Planes of great Circles do always cut one another in halves by Diameters, which are straight Lines passing through the common Center; therefore Lines drawn from the Center of the Dial, to the Intersections of the Hour-circles with the great Circle of the Plane, shall be those Sections, and the Hour-lines of the Dial.

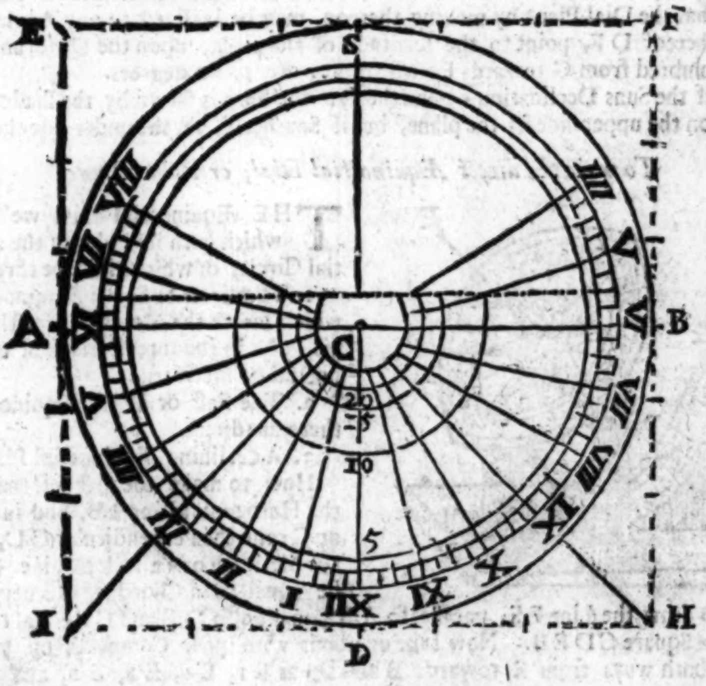
11. Every Dial-Plane being an Horizon to some place in the Earth (as was said, *Theorem* 1.) hath his proper Meridian, which is the Meridian passing through the Poles of the Plane, and making Right Angles with the Plane. If the Poles of the Dial Plane lie in the Meridian of the Place, then is the Meridian of the Plane all one with the Meridian of the Place, and the Gnomon or Style shall stand erected upon the Noon-line, or Line of 12 a Clock, as in all direct Dials. But if the Plane decline, then shall the Substyle Line, or Line which the Gnomon standeth upon (which is the Meridian of the Plane) vary from the Line which is the Meridian of the Place; and this Variation shall be East, if the Declination of the Plane be West: And contrarily, because the Visual lines, by which the Sphere is projected on Dial Planes, do, like the Beams in a Burning-glass, intersect or cross one another in a certain Point of the Gnomon (to be assigned at pleasure) called the Nodus, and so do all shadow themselves on the Dial Plane, beyond the Nodus, the contrary way.

12. Dials are most aptly denominated from that part of the Sphere where their Poles lie, though some Authors have chosen to denominate them from the Circles in which Planes lie; as the Dial-Plane which lieth in the Æquinoctial, (or parallel to it) is called by many an Æquinoctial Plane; but I concur with those who would rather call it a Polar Plane, because the Poles thereof are in the Poles of the World.

To make a Polar, commonly called an Equinoctial Dial, and how to place it.

THe Plane of the Polar Dial lieth in the Æquinoctial, where the 12 Meridians or Hour-circles divide both the Æquinoctial and this Plane into 24 Hours or equal Parts; the Gnomon stands upon the Center at Right-Angles with the Plane.

First, draw the Horizontal Line A B, and cross the same at Right Angles with the Line C D: Now on the Center at C, with the Chord of 60 Degrees, describe the Circle A B D S, and about it make the Square E F H I; then take out of the Line of Hours one hour, and lay it from each Corner, as E, F, H, I, both ways: Also do the like with two Hours, and from the Center at C draw Lines to those Hour-points: So shall



you have the Hour-lines in the Æquinoctial Dial, C D being the Meridian or 12 a Clock Line, and A B the East and West Line, being for 6 in the Morning at B, and 6 in the Afternoon at A, and so number the rest of the Hours in order: You need draw no more hours than from 4 in the Morning unto 8 at Night, for this Latitude of *Bristol*, being near 51 deg. 30 min.

For the Gnomon or Stile, you must have a straight Pin or Wire set upright in the Center, of such length as you see convenient; but if you will have it of such a length, as to shew the Suns Declination, you may find it by the following direction.

To find the length of the Stile, and Semidiameters of the Parallels of Declination by Trigonometry.

If it were required to proportion the Stile to the Plane, suppose the Semidiameter of the greatest parallel upon the Plane were but 6 Inches, and the Parallel should be of 5 deg. of Declination, the Rule is,

As the Tangent of 45 deg.	10.00000
Is to the Tangent of the parallel of Declination 5 deg.	8.94195
So is the Semidiameter of the Plane 6 Inches C 5	0.77815
To the length of the Stile 52 parts	1.72010

Which shews that the length of the Stile must be $\frac{52}{100}$ parts of an Inch.

By the length of the Stile, to find the Semidiameter of the Parallel of Declination.

Suppose the length of the Stile above the Plane to be 1 Inch, and you were to find the Semidiameter of the Tropick, whose Declination is known to be 23 d. 30 m. the Rule for this or any other Parallel of Declination,

As the Tangent of 45 deg.	10.00000
Is to the length of the Stile 1 Inch	0.00000
So is the Co-tangent of Declination 23 deg. 30 min.	10.36170
To the Semidiameter of this Parallel 2 Inches $\frac{30}{100}$	0.36170

Which shews the Semidiameter of the Tropick to be 2 Inches $\frac{30}{100}$. So if the Declination be 20 deg. the Semidiameter will be 2 Inches $\frac{74}{100}$; if 15 deg. then $3\frac{73}{100}$; if 10 deg. then $5\frac{67}{100}$; if 5 deg. then $11\frac{44}{100}$; and so of any other height of the Stile.

This Dial will shew the hour of the Day in all Latitudes, if it be fitted as in the following Figure; that is, if two small Pins be fastned in the Hour-lines of Six on both sides, so that the Dial Plane by moving thereon, may be inclined to any Angle, till the Gnomon thereof D F, point to the Latitude of the place, upon the Quadrant G D F; which is numbred from G towards F with 10, 20, *&c.* to 90 degrees.

Note, if the Suns Declination be Northerly, the hour is shewn by the shadow of the Gnomon on the upper side of the plane, but if Southerly, on the under side thereof.

To make the direct Æquinoctial Dial, or Polar Plane.

THE Æquinoctial Dial we call that which hath its Poles in the Æquinoctial Circle, of which there be three kinds.

1. The direct or South Æquinoctial Dial, which faceth the Meridian directly, having his Poles in the Intersections of the Æquinoctial or Meridian.

2. The East or West Æquinoctial Dial there are direct.

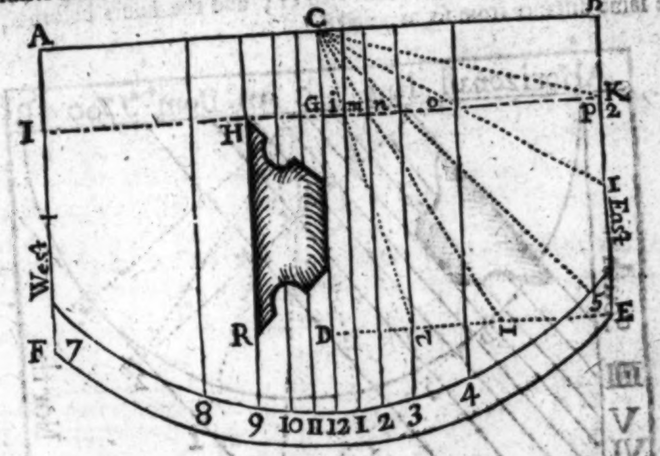
3. A declining Æquinoctial Plane.

How to make the first of these, draw the Horozontal Line A B, and in the midst at C raise the Perpendicular C D, which is the Meridian or 12 a clock Line. Let C D be equal to a Chord of 60 degrees, and through D draw the Line F E, parallel to A B; make also D E and C B equal to D C, so have you a Square C D E B. Now take one hour with your Compasses off your Scale, and lay it both ways from E towards B and D, as E 1, E 1, E 2, E 2, and draw the prick'd

prick'd Lines from C to these Points. Then drawing a Line through G, determin'd by the height of the Stile E G, parallel to the Horizon, as I K, you shall find it cut the former Lines drawn from the Center C, in the Points I, m, n, o, p: through which Points, if you draw Parallel-Lines to the 12 a clock Line C D, you shall have all the afternoon hours as far as 5, and the morning hours must be drawn in like manner and distance on the West side, from 7 in the morning unto 12, as in the Figure following.

Note, that the height of the Stile is always 3 hours from the Meridian, as you see H G, which you may make with Copper or Brass Plate, Iron, in form as you see shadowed whose breadth on the top is here H R, which may be made more or less as you please.

This Dial will serve in any Latitude, if the Plane be parallel to the Plane of the hour of 6, and so parallel to the Axis of the World.



To find the Height of the Stile of the Hour-distances from the Meridian by the Logarithms.

Suppose the length of the Horizontal Line A B or F E be 12 Inches, and that it were required to put on all the Hours from 7 in the Morning to 5 in the Evening; here we have for 5 hours, 6 inches on either side of the Meridian, wherefore allowing 15 degrees for an hour, to find the height of the Stile proceed thus:

	1057195
As the Tangent 75 deg. (for 5 hours)	077815
Is to the distance from the Meridian 6 inches	1000000
So is the Tangent of 45 Degrees	020620
To the height of the Stile 1 Inch $\frac{64}{100}$	

To the height of the Stile 1 Inch $\frac{64}{100}$ from the Meridian, will be 1 inch

And likewise the distance of the hours of 9 and 13 from the Meridian, will be 1 inch and $\frac{64}{100}$ parts.

To find the Hour-distances from the Substile or hour of 12.

Having found the length of the Stile to be 1 inch $\frac{64}{100}$ parts, we find the rest as follows:

Example for the hours of 11 *and* 1, *say,*

As the Tangent of 45 deg.	1000000
Is to the Tangent of the hour from the Meridian 15 deg.	942805
So is the height of the Stile $1\frac{64}{100}$ inches	020620
To the distance from the Meridian or Substile $\frac{44}{100}$ inches	963425

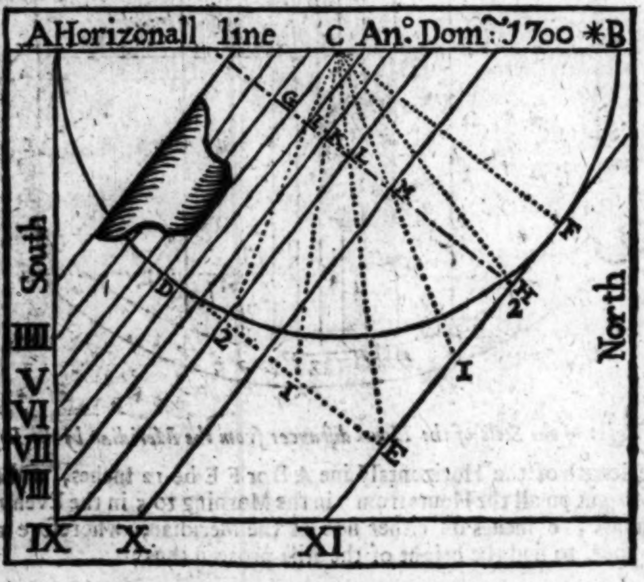
Hours.		An. Po. deg.	An. Po. min.	Tang. In.	Tang. Par.
12		0	0	0	0
11	1	15	0	0	43
10	2	30	0	0	93
9	3	45	0	1	61
8	4	60	0	2	79
7	5	75	0	6	0
6	6	90	0	Infinite.	

Then the Hour distance of 1 and of 11 taken from a Scale of Inches divided into 100 parts, and prick'd from C and D both ways from B A and E F, and draw the Hour-Lines parallel to the Meridian; and so do with the other hour distances in the Table until it be finished.

How

How to make the East or West Æquinoctial Dial, Lat. 51 d. 30 m.

FIrst, for the East Plane draw the Horizontal Line A C B, and on the Center C, with a Chord of 60 deg. describe the Semicircle A D B, and prick off the Chord of 51 deg. ½ from A to D, and the Chord of 38 deg. ½ from B to F, and draw the Lines C D and C F, then making F E and D E equal to C D or C F, finish the Square C D E F. And from the Corner at E, lay down both ways towards D and F the hours of 1 and 2, from whence draw Lines to the Center C: Next make choice of the height of your Stile, which lay down from C to G on the 6 hour Line, drawing from the Point G a Line Perpendicular to the Line of 6, or parallel to C F, as G H, which cuts the former Lines in the Points I K L M H; through which Points drawing Lines parallel to the hour of 6, you shall have the Morning hours from 6 to 11; and the hours before 6, as 5 and 4 as are of the same distance from six as 7 and 8.



How to make the West Æquinoctial-Dial.

The West Plane is Delineated in all respects like the East, only when you have described the Semicircle A D B, you must lay the Chord of the Latitude 51 deg. ½ from B which will give the Point D, and the Chord of 38 deg. ½ the Complement of the Latitude, from A for the Point F; then proceed as before in the East Plane, numbring the Hour-lines with the hours 1, 2, 3, 4, 5, 6, 7, and 8 Afternoon. The Stiles height and hour distances, are found by the Logarithms, as in the South Æquinoctial Plane, reckoning your hours from 6, which is the Substile.

For Example. Suppose the distance C F for the hour of 11 on the East Plane, were 37 Inches [illegible]; the perpendicular height of the Stile is 1 Inch, the distance G m is 1 inch [illegible], and G l 1 Inch, G k [illegible], and G i [illegible] of an inch.

Of the kinds of Oblique-Dials.

WHat an Oblique Dial is, and why it hath been so called, hath already been shewed.

They be { Direct, or Declining } { Either of which may be } { Erect, Recline, or Incline } to the Horizon.

Direct Dials have their Poles in the Meridian or Prime Vertical. Decliners have their Poles in some other Azimuth.

Erect Dials make Right Angles with the Horizon, Incliners and Decliners make Oblique Angles therewith.

Some Planes both Decline, Recline, or Incline, and are the most difficult to be delineated.

The

The Declination of a Plane is the Azimuthal distance of its Poles from the Meridian of the place, Eastward or Westward.

The Reclination or Inclination of a Plane is the Angle made by the Axis of the Plane, and the Axis of the Horizon.

How to make the Vertical Dial, commonly called the Horizontal Dial.

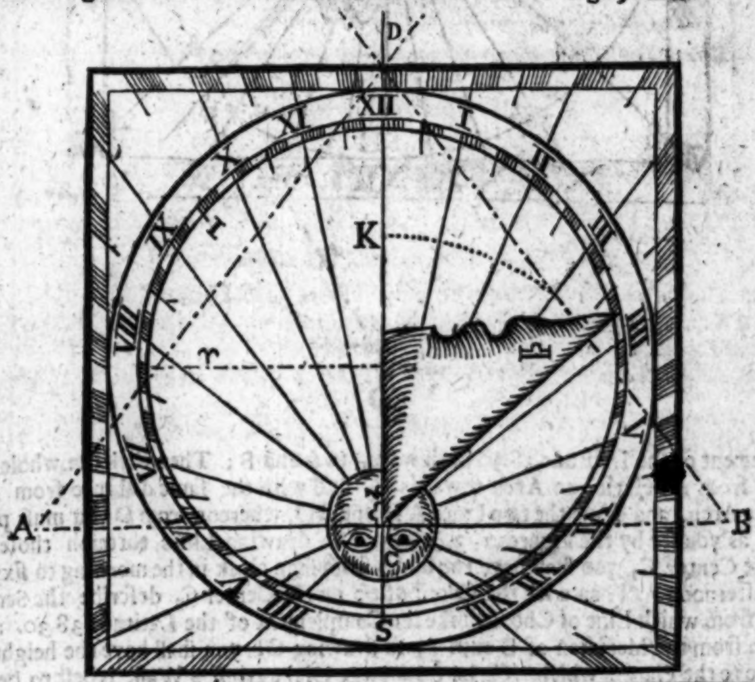
DRaw first the Horizontal-line A B, which is the Hour-line of 6; then take the Latitude of 51 deg. 30 min. from the Gnomon-line, and lay it down both ways from the Center C to A and B; then take the whole Line of 6 hours, fixing one Leg of your Compasses at A, describe a little Arch towards D; do the like from the Point B, crossing the former Arch at D; so draw the Line A D and B D. Now upon these Lines you must place the 6 hours on the Scale from D unto A, and also from D unto B, that is the hours of 1, 2, 3, 4, 5, from whence drawing Lines from the Center C, you shall have the hours as you see numbred from 4 in the Morning until 8 in the Afternoon, which suffice for this Latitude.

For the Stiles height, with a Chord of 60 deg. describe the Arch K E, and lay the Chord of the Latitude 51 deg. ½ from K to E, then from the Center C draw the Line C E, which is the Stile for this Dial.

To find the Hour-distances by the Logarithms.

Example for 1 hour from 12.

As the Sine of 90 deg. is to the Sine of the Latitude 51 deg. 30 min.	989354
So is the Tangent of 15 deg. for 1 hour	942805
To the Tangent of the Hour-distance from the Merid. 11 deg. 50 min.	932159



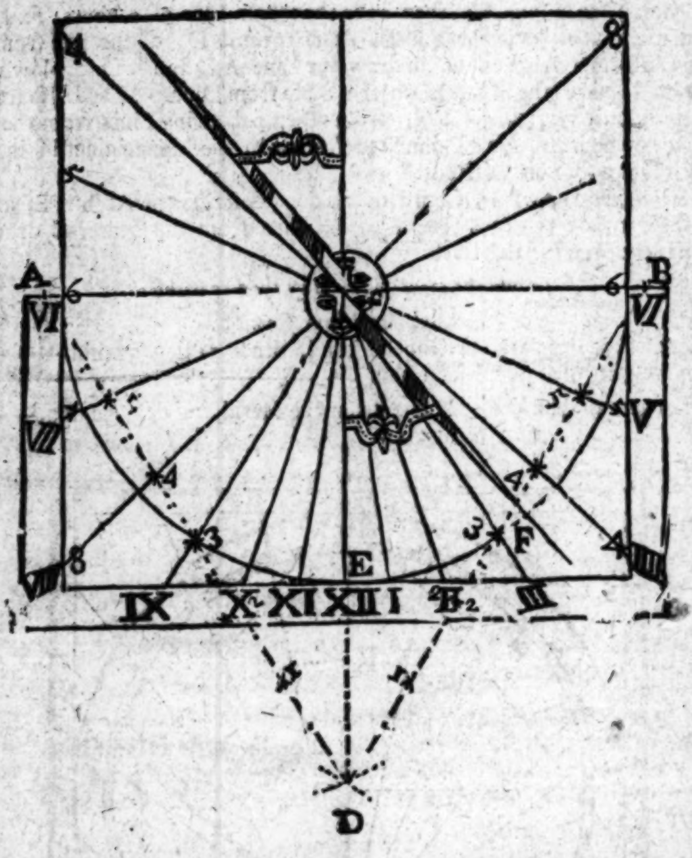
In this Table you have the distance of 5 hours on either side the Substile, or hour of 12, which take from the Line of Chords, and prick from the hour of 12 on the Arch K E on each side; and by the same Rule that you found the hours you may find the Quarters, and prick them off in like manner.

Hours.	*Gr.*	*min.*	*Gr.* *Tangents.*	*min.*
12	00	00	00	00
1	15	00	11	50
2	30	00	23	20
3	45	00	28	03
4	60	00	53	35
5	75	00	71	06

A South or North Horizontal Dial, commonly called, an upright North or South-Dial, and how to make it.

THis belongs to an upright Wall looking full North or South, and the Plane of it lies in the prime Vertical.

First, draw the Horizontal-line A B, which serveth for 6 in the morning at A, and 6 in the afternoon at B, then from the Center C lay down from the Line of Latitudes the



Complement of the Latitude 38.30 both ways, to A and B: Then with the whole Line of 6 hours from A describe an Arch towards D, and with the same distance from B cross the same Arch, and draw the two Lines A D and B D, whereon from D you must place the Hours, as you see by the Figures 1, 2, 3, 4, 5. So drawing Lines through those Points from the Center C, you shall have the hours from six a clock in the morning to six a clock in the afternoon. Then with the Chord of 60 on the Center C, describe the Semicircle A E B, from which Line of Chords take the Complement of the Latitude 38.30. and lay it down from the Meridian of E unto F, so drawing C F you shall have the height of the Stile above the Plane; which, if it be for a large Dial against a Wall, is best to be a Rod of Iron; for small Dials a Brass Plate is best.

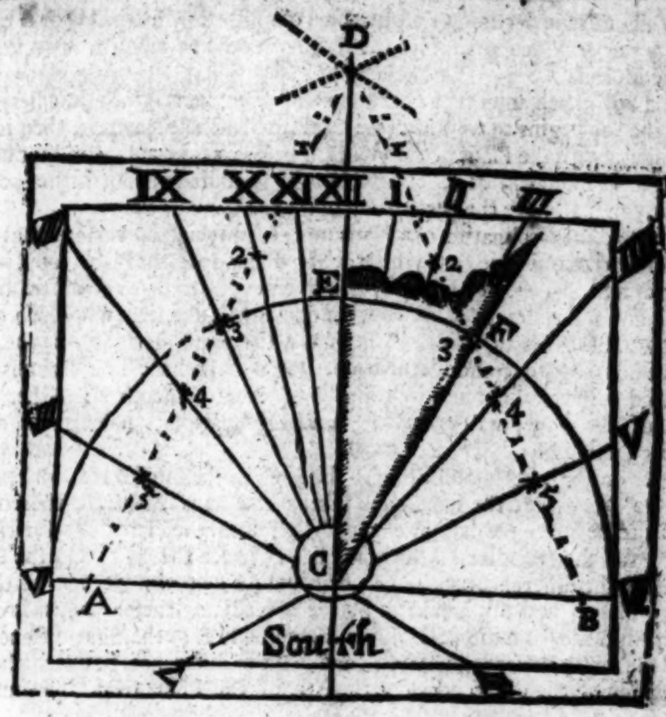
The South Dial shews the Hours from 6 in the morning to 6 at night: The other hours before and after 6, as far as four and eight belong to the North Face of this Dial.

The North Plane shews the hours from 4 in the morning to 8, and from 4 in the afternoon till 8 at night, the Sun shining no longer thereon in this Latitude; and as in the South Plane the Stile points downwards towards the South Pole, so in the North Plane it points upwards towards the North Pole.

To delineate a South Plane Reclining 67 deg. the Lat. 51 deg. 30 m. Northerly.

IN South Recliners or North Incliners, the difference between the Complement of the Latitude of the place, and the Reclination or Inclination is the Stiles height.

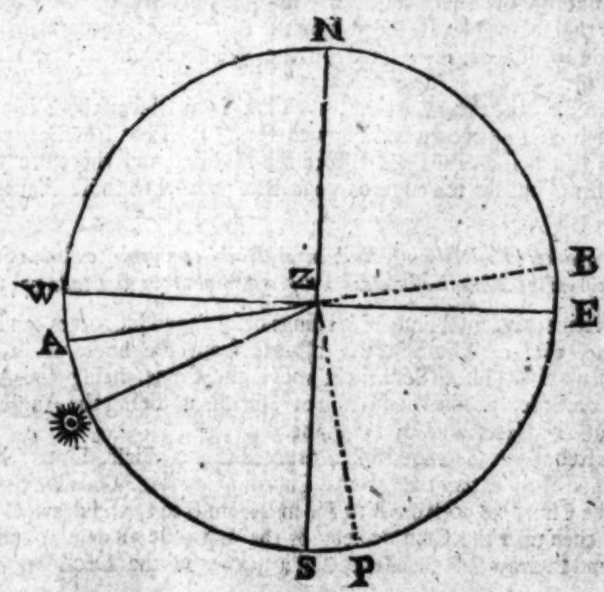
In



In North Recliners or South Incliners the ſum of the Complement of the Latitude, and the Reclination is the Stiles height, which if it exceeds 90 deg. ſubtract it from 180 deg. the remainder is the Stiles height. So in this Plane the Stiles height is 28 deg. $\frac{1}{2}$; and you may delineate the Plane as if you were to draw an Horizontal Dial for the Lat. of 28 d. $\frac{1}{2}$.

To find the Declination of a Plane.

ALL perpendicular Planes, as Walls, lie in ſome Azimuth, whoſe Planes cut both Zenith and Nadir, and the Center of the Earth, as in the Figure, Z is Zenith; E S W N, the Horizon, E W is the Horizontal Line drawn upon a Wall or Plane, looking full South or North, its Poles are at S and N in the Meridian; wherefore it declineth not.



AB

A B is a Wall or Plane declining East by the Arch S P, to which A W or B E are equal: For as much as the Wall declineth from the East Azimuth, so much doth its Pole at P decline from the Meridian.

Now to find how much any Plane declineth, and so in what Azimuth it lies, one way is this: When the Sun begins to enlighten the Wall, or when he leaves it, then is the Sun in the same Azimuth with the Plane of the Wall; Therefore take at that instant his Altitude, and thereby get his Azimuth, as in the Sixth Book, so adding or subtracting 90 deg. to the Suns Azimuth, you shall have the declination of the the Wall or Plane.

But you may find the Declination of a Plane more readily and universally thus; Upon the Plane draw an Horizontal Line, and when the Sun shines upon the Plane, apply thereto the fiducial edge of a Semicircle, or some other Instrument fit to take the differ. between the Suns Azimuth and the Azimuth of the Plane, and at the same time while you observe this difference of Azimuths let another take the Suns Altitude; This done, by the Latitude of the place, the Suns Altitude and Declination, you may find the Suns Azimuth, and this being compared with the difference of the Planes Azimuth therefrom, either wanting or past the Pole of the Plane, will give the Planes Declination; an Example or two will render it more intelligible,

Example 1. In the Afternoon I observe the Sun (to the Westward, or) past the Pole of the Plane 72 deg. and at the same time taking the Suns Altitude, thereby I find the Suns Azimuth to be South 62 deg. West, and therefore the Planes Declination is South 10 deg. East; for the Meridian of the place lies between the Sun and the Pole of the Plane, therefore the difference between 72 deg. and 62 deg. *viz.* 10 deg. is the Declination of the Plane; and this is evident by the preceding Scheme, wherein P ☉ represents the Suns distance from the Pole of the Plane, and S ☉ the Suns distance (or Azimuth) from the South towards the West, and S P the difference between those Arches, is the Declination of the difference of P the Pole of the Plane from the South towards the East.

Example 2. In the Forenoon the Suns distance from the Pole of the Plane wanting (or to the Eastward thereof) is 30 deg. and the Suns Azimuth (found by its Altitude) is S 46 E, and the Declination of the Plane is South 10 deg. Easterly.

And thus if you draw a Scheme, you may soon reason out the Declination, better than do it blindfold, by the Rules commonly given: And this serves not only of upright Planes, but of Recliners, or Incliners also.

How to find the Declination by the Needle when the Sun doth not shine.

Apply the North side of a Square Box wherein there is fitted a Magnetical Needle unto the Wall, and hold it Horizontally as near as you can, that the Needle may have Liberty to play too and fro; and when it stands still observe upon the Limb of the Chard over which it moves, upon what degree the Needle stands, for that is the Declination of the Plane, pointed out by the South Point of the Needle: And if you would know the Coast, observe, that if the Needle stand upon the East side of the Meridian Line, then is the Declination West; but if it stand on the West side of the Meridian Line, the Declination is East.

In using the Needle take these Cautions, 1. That in all places there is a variation of the Needle, which must be known and allowed for. 2. That Iron Bars and Casements in Windows, as also Brick Walls will distort the Needle, and therefore you must not come too near them, but set the edge of your Box parallel to those Planes at some convenient distance.

How to find the requisites in a Declining Horizontal Dial, commonly called a South erect Decliner, declining from the South Eastwards 32 deg. 30 min. in the Latitude of 51 deg. 30 min.

IN upright Decliners we must find three things before the Hour-lines can be drawn upon the Plane, *viz.* 1. The Substiles distance from the hour of 12, which is the Planes Perpendicular. 2. The Stiles height above the Plane, being the Angle betwixt the Substile and the Stile. 3. The Inclination of Meridians, being the Angle between the two Meridians of the place, and of the Plane.

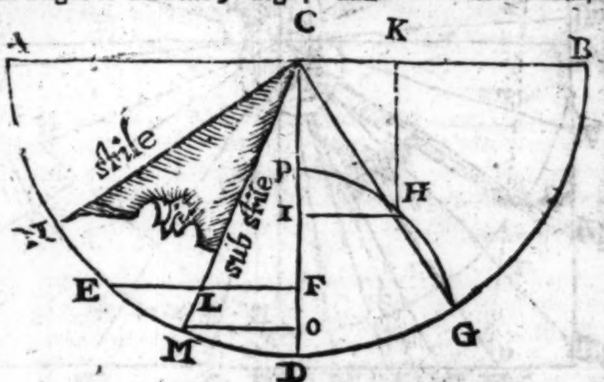
To find these Requisites Geometrically, proceed thus; First, Draw the Horizontal line A B, and upon the Center at C, with a Chord of 60 deg. describe the Semicircle A D B, and lay the Chord of 90 from A to D, and from B to D, and draw C D for the line of 12 a Clock; then take the Complement of the Latitude 38 deg. 30 min. and lay it from D to E, and so draw E F parallel to A B; next take the Declination of the Dial

32 deg. 30 min. and lay it from D to G, drawing the Radius C G, thereon you must lay the distance E F from C to H. Now the nearest distance from H to the Meridian C D, as H I, lay from F to L; then draw a Line from C through L, it will cut the Limb in the Point M; so measuring D M on the Line of Chords, you shall have the Substiles distance 23 deg.

By Logarithms. As the Radius 90 deg.——————1000000
Is to the Sine of the Declination F E 32 deg. 30 min.——973021
So is the Co-tangent of the Latitude 51 deg. 30. min.——990060
To the Tan. of the Substiles distance from the Meridian 23 d. 8 m.——963081

For the height of the Stile, take the nearest distance from H to the Line A B, as H K, and lay the same from L to cut the Arch D A (extended if need be) in N. So measure M N, on the Line of Chords gives the height of the Stile 31 deg. ½.

As the Radius 90 deg.——————1000000
Is to the Co-sine of the Latitude 51 deg. 30 min.——979414
So is the Co-sine of the Declination 32 deg. 30 min.——992602
To the height of the Stile 31 deg. 40 min.——972016



To find the Inclination of Meridians.

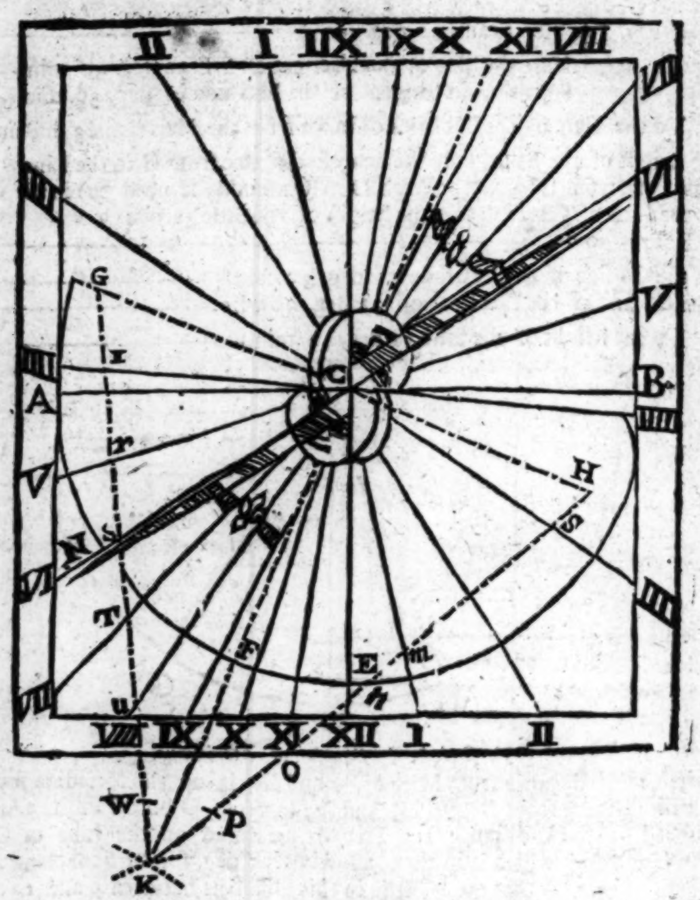
Take the nearest distance from M to F E, and lay it on the Meridian from F to O: Then take the distance from O unto G, and lay it from O unto P on the Meridian (extended if need be) so the distance from P to M, measured on the Line of Chords, will be found to be 39 deg. which is in time (allowing 15 deg. for an hour, and 4 min. to a deg.) 2 hours 36 min. So that the Substile in this Dial falls between 9 and 10 of the Clock in the Morning.

By Logarithms. As the Radius 90 deg.——————10
Is to the Sine of the Latitude 51 deg. 30 min.——989354
So is the Co-tangent of the Declination 32 deg. 30 min.——1019581
to the Co-tangent of the Inclination 39 deg. 9 min.——1008935

To draw the Hour-lines in a Declining Horizontal, or South erect Dial, declining 32 d. 30 m. from the South Eastward, the Latitude 51 deg. 30 min.

First, draw the Horizontal Line A B, and on the Center at C describe the Semicircle A E B, with the Chord of 60 deg. and from A and B lay down 90 deg. unto E; and draw C E the Meridian Line or Hour of 12; then take the Substiles distance 23 d. and lay it from E unto F, and from the Center C through F draw C F K the Substile; then take the Chord of 90 deg. and lay it from F both ways upon the Arch, and draw the Line G H, whereon lay the Stiles height 31 deg. 40 min. taken from the Line of Latitudes, and laid from C to G and H. Then take the whole Line of 6 hours, and with that distance from G describe an Arch at K, and with the same distance from B cross the said Arch, and draw the Lines G K and H K: which last Line cuts the Meridian at n, and if you measure K n on the Line of 6 hours, you shall find it 2 hours 36 min. being the Inclination of Meridians. Then take one hour more, which is 3 hours 36 min. and lay the same from K unto M; and so increasing one hour more, you shall have the Points *l* and S; also diminishing one hour less than 2 hours 36 min. which is 1 hour 36 min. the same will reach from K to O, and so 38 min. from K to P. Now the same distances that

that are laid from K towards H, must be laid from G towards K, in the points x, y, S, T, u; so drawing the Lines from the Center C through those Points, you shall have the Hour-lines, as you see in the Dial following.



How to Calculate the Hour-distances by the Logarithms.

Example. To find the distance of the hour of 10 from the Substile. The Angle betwixt the hour of 10 and the Substile is 9 deg. 9 min.

As the Radius ——————————— 1000000

Is to the Sine of the Stiles height 31 deg. 40 min. ——————— 972013

So is the Tangent of the Angle from the Substile 9 deg. 9 min. ——— 920701

To the Tangent of the Hour-distance from the Substile 4 deg. 50 min. —— 892714

And so you may find the distance of any other Hour-line, from the Substile, as in the following Table, under the Title of Hour-distances.

In this Table the Angles of the Hour-lines with the Substile, under the Title of Hour Angles, are thus found. From the Inclination of Meridians 39 deg. 9 min. subtract 15 deg. leaves 24 deg. 9 min. for the hour of 11; from 24 deg. 9 min. subtract 15 deg. leaves 9 deg. 9 min. for the hour of 10; then subtract 9 deg. 9 min. from 15 deg. leaves 5 deg. 51 min. for the hour of 9; to 5 deg. 51 min. add 15 deg. makes 20 deg. 51 min. for the hour of 8; and so continue to add 15 deg. till you make 80 deg. 51 min. for the hour of 4 in the Morning: Likewise add 15 deg. to 39 deg. 9 min. makes 54 deg. 9 min. for the hour of 1; and 15 deg. more makes 69 deg. 9 min. for the hour 2, and 15 deg. more makes 84 deg. 9 min. for the hour of 3 Afternoon.

Thus

Thus was this Table made; and so you may make one for any Latitude, and for any Declining Dial; and by it prove your former Work: For if you prick from the Substile C F the Chord of 4 deg. 50 min, and draw a Line from the Center, it will be the Hour-line of 10; and prick the Chord of 3 deg. 5 min. from the Substile, and draw a Line through that Point to the Center, and it will be the Hour-line of 9 a Clock; and so of the rest, as you find them in the last Column.

Hours.	Hour-Angles.		Hour-Distan. from	
	D.	M.	D.	M.
4	80	51	72	57
5	65	51	49	30
6	50	51	32	49
7	35	51	20	46
8	20	51	11	18
9	5	51	3	5
	Meridian.		Substile.	
10	9	9	04	50
11	24	9	13	15
12	39	9	23	8
1	54	9	36	0
2	69	9	54	2
3	84	9	78	57

Note, That because the Plane declines East, therefore the Substile shall decline West: For the Dial being such a Projection of the Sphere, wherein all the usual Lines cross in the Nodus of the Gnomon, and thence disperse themselves again towards the Plane; therefore that which is East in the Sphere, will be expressed West on the Plane, and contrarily as was said in *Theorem* 11. Again consider, that howsoever the Plane be declined East or West, the Gnomon is fixed, because it is a part of the Axis of the World, or a Line parallel to it. Now therefore move a South Dial and make it decline East, holding the Gnomon unmovable, the West side of the Dial will approach nearer to the Gnomon.

And if you would draw the North Dial on the opposite side of this Plane, prolong those Hour-lines, and the Substile upwards beyond the Center, and you have the North Dial beyond C, or above the Horizontal Line A B, and the South Dial below it.

How to delineate an East or West Reclining or Inclining Dial.

AS the Horizontal line of a South Recliner lieth in the East Azimuth, so the Horizonal line of an East Recliner lieth always in the Meridian of the Place: And as all Declining Planes lie in some Azimuth, which cross one another in the Zenith and Nadir, so these Reclining Planes lie in some Circle of Position, which cross one another in the North and South Points of the Horizon; which being considered, these East and West Incliners and Recliners, shall be made as easily as the upright Decliners. For these Dials are upright Decliners to those that live 90 deg. from us Northward or Southward, who have one of their Poles elevated as much as the Complement of our Latitude.

To find the Reclination or Inclination of a Plane, proceed thus; On the Plane draw an Horizontal Line, and cross it at Right Angles, that Line is the Planes Perpendicular, to which apply the streight edge of a long Ruler that may over-hang the Plane, and to this edge of the Ruler apply the fiducial Ray of a small Quadrant, the Plumb-line playing upon the limb of the Quadrant, will give you the Reclination or Inclination of the Plane.

To find the Substile distance from the Hour of 12, *by Logarithms.*

As the Radius —————————————— 1000000
Is to the Sine-Complement of Reclination 45 deg. ———————— 984948
So is the Tangent of the Latitude 51 deg. 30 min. ———————— 1009939
To the Tangent of the Substiles distance 41 deg. 38 min. ———————— 994887

Or upon *Gunter*'s Ruler, extend the Compasses from the Sine of 90 deg. to the Sine of 45 deg. the same extent will reach from the Tangent of the Latitude 51 deg. 30 min. to 41 deg. 38. min.

Secondly, The height of the Stile above the Plane is found thus by the Logarithms.

As the Sine of 90 —————————————— 1000000
to the Sine of 51 deg. 40 min. ———————————— 989354
So is the Sine of Reclination 45 deg. ———————————— 984948
To the Sine of the Stiles height 33 d. 36 m. or Pole above the Plane- —— 974302

Extend the Compasses from the Sine of 90 deg. to the Sine of 51 deg. 30 min. the same Extent will reach from the Sine of Reclination 45 deg. to 33 deg. 36 min. the height of the Stile.

3. To

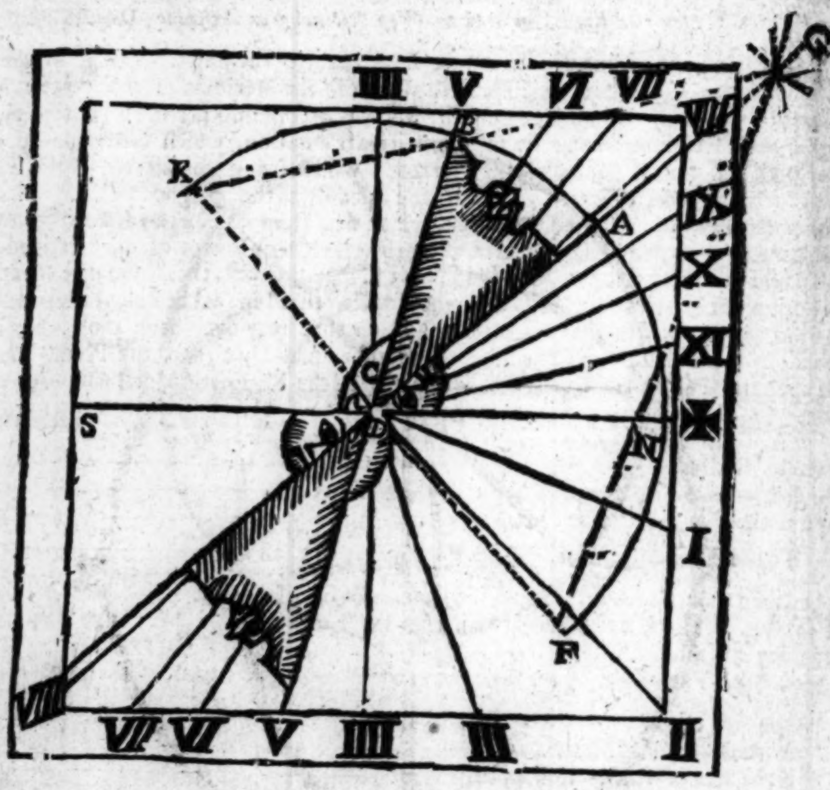
3. To find the Inclination of Meridians by the Logarithms.

As the Sine of the Latitude 51 deg. 30 min.	989354
To the Sine of 90 deg.	1000000
So is the Sine of the Substiles Distance 41 deg. 38 min.	982240
To the Sine of Inclination of the Meridians 58 deg. 05 min.	992886

Extend the Compasses from the Sine 51 deg. 30 min. the Sine of 90; the same Extent will reach from 41 deg. 38 min. the Substiles distance, to 58 deg. 05 min. which resolved into time, doth make about 3 hours, 52 min. and so the Substile will fall near the hour of 8 in the Morning.

To draw the Hour-Lines on the East Recliner.

Draw the Planes Horizontal Line S N, which is Hour of 12 in East and West Incliners, or Recliners; then with the Chord of 60 deg. describe the Arch F A K, and set off the Substiles distance 41 deg. 38 min. from N to A, and draw the Substile C A, and cross it at Right Angles with the Line F C K, then set off the Stiles height 33 deg. 36 min. from A to B, and draw the Stile C B: Then take off the Stiles height 33 deg. 36 min. from the Line of Latitudes, and lay it from C to F and K, then with the distance of 6 hours from the Scale, setting your Compasses at F, and then at K, describe the two occult Arches at G, and to their intersection draw the Lines F G and K G. From the Scale of six hours take the Inclination of Meridians 3 hours, 52 min. and laying it from G it will reach to N (in the Line G F) for the hour of 12, and from K it will reach in the Line G K to the Point where the hour of 6 intersects that Line: so take the distance of 4 hours, 52 min. and set off from G on the Line F G, for the hour of 1 Afternoon, and the same distance from K on the Line G K, for the hour of 7 in the Morning; in the same manner place the distance of 5 hours, 52 min. from G for the



hour of 2, and from K for the hour of 8; likewise the distance of 2 hours, 52 min. from G for the hour of 11, and from K for the hour of 5; and so the distance of 1 hour, 52 min. from G and K for the hours of 10 and 4, and the distance of 52 min. from G for the hour of 9; through these Points draw the Hour-Lines, and finish your Plane. The hours proper for this Plane, are from 4 in the Morning till 2 in the Afternoon. If you continue

continue the Substile, the stile and hours of 4, 5, 6, 7, and 8 in the Morning below the Center C, they shew how they will fall upon a West Plane inclining 45 deg. with this caution, that the hours of 1, 2, &c. in the Afternoon which are here on the North side of the East Plane, must be placed there on the North side of the West Plane, and so for the hours of 5, 6, 7, and 8, on the South side of the Plane.

Of Declining, Recl ining, or Inclining Plants.

These Planes are the most difficult in their delineation, and are of several kinds.

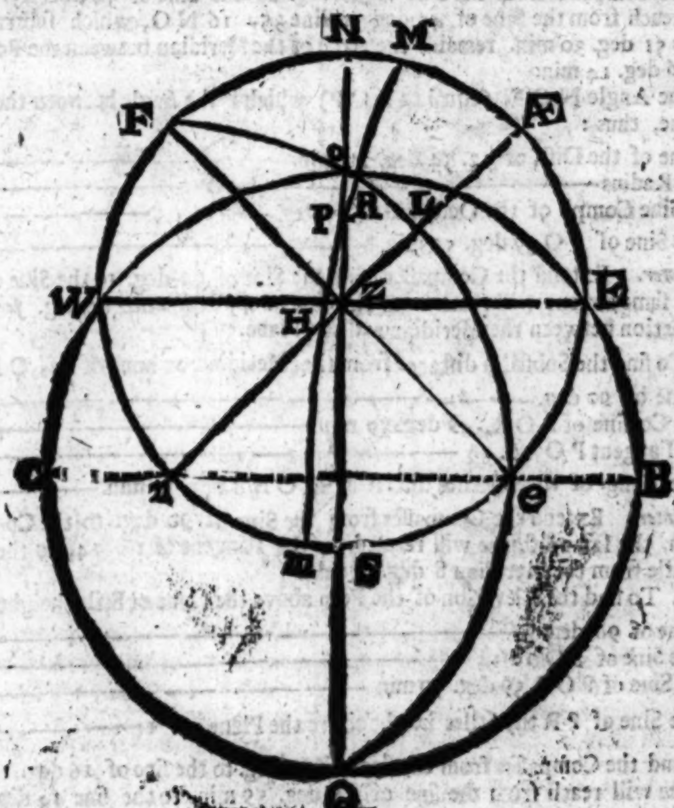
I. South Recliners and North Incliners, declining East or West, which are of three sorts: 1. Such as Recline or Incline between the Zenith and the North (or Elevated) pole, whose Reclining Planes behold the South Pole, and Incliners the North Pole. 2. Such as Recline or Incline to the Pole, and are called Polar Decliners. 3. Such as Recline or Incline to between the North Pole and the Horizon, the Recliner beholding the North Pole, and the Incliners the South Pole.

II. North Recliners, and South Incliners, declining East or West, which are likewise of three sorts: 1. Such as Retline or Incline, so as to intersect the Meridian of the place, between the Zenith and the Equinoctial. 2. Such as Recline or Incline, so as to intersect the Meridian in the point where the Equinoctial intersects it, and are called Equinoctial Decliners. 3. Such as Recline or Incline so as to intersect the Meridian between the Equinoctial and the Horizon.

How to find the requisites, and how to delineate a South Reclining or North Inclining Dial.

A South Plane declining 45 deg. Westerly, and Reclining 45 deg. in the Latitude of 51 deg. $\frac{1}{2}$ Northerly. In these Planes there are 4 things to be found before we can draw the hour Lines.

1. The distance of the Meridian (or hour of 12) from the Horizontal Line of the Plane, or from the perpendicular thereof.
2. The Substiles distance from the hour of 12, or from the Planes perpendicular.
3. The Stiles height.
4. The Inclination of Meridians, which are illustrated in the following Scheme.



In this Scheme the Arch F L E is the Plane, Z L the Reclination thereof, F E the Horizontal Line of the Plane, and Æ n the Vertical Line of the Plane, or the Planes Perpendicular, S n is the Declination of the Plane, m H P M the Meridian of the Plane or Substile, passing by the North Pole at P, cutting the Plane at Right Angles at R, and passing through the Pole thereof at H, F o the distance of the hour of 12 from the Planes Horizontal Line; O R the Substiles distance from the hour of 12, R L the Substiles distance from the Planes Perpendicular, P R the Stiles height or the Elevation of the North Pole above the Plane; O P R the Inclination of Meridians.

To find the distance of 12 from the Horizontal Line of the Plane, say,

As the Sine of 90 ———————— 1000000
To the Sine Comp. of the Reclination 45 deg. ———————— 984948
So is the Tangent of Declination 45 deg. ———————— 1000000
To the Co-tangent of 54 deg. 45 min. ———————— 984948

Which is the Arch of the Plane between the Horizon and Meridian, or the distance of the hour of 12.

By the Gunter. Extend the Compasses from 90 to 45 upon the Sines, the same Extent will reach from the Co-tangent 45 to Tang. 35. 15, whose Comp. 54 deg. 45 min. is the distance of 12.

To find the Substiles distance from the hour of 12 O R, we must find two things adjutory thereto, *viz.* N o, the Arch of the Meridian between the Plane and the Horizon, and F o N the Angle betwixt the Plane and the Meridian.

To find N O the distance in the Meridian from the Plane to the Horizon.

As the Sine of 90 deg. ———————— 1000000
To the Sine of the distance of 12. 54. 45 ———————— 991203
So is the Sine of the Reclination 45 deg. ———————— 984948
To the Sine of N O 35 deg. 16 min. ———————— 976151

Extend the Compasses from the Sine of 90 deg. to the Sine of 54 and 45, the same Extent will reach from the Sine of 45 deg. to Sine 35, 16 N O, which subtracted from the Latitude 51 deg. 30 min. remains the Arch of the Meridian between the Pole and the Plane O P 16 deg. 14 min.

To find the Angle N O F, (equal to R O P) which is the Angle between the Meridian and the Plane, thus:

As the Sine of the Dist. of 12. 54 deg. 45 min. ———————— 991203
To the Radius ———————— 1000000
So is the Sine Compl. of the Declination 45 deg. ———————— 984948
To the Sine of F O 59 deg. 59 min. ———————— 993745

By the Gunter. Extend the Compasses from the Sine of 90 deg. to the Sine of 54 deg. 45 min. the same Extent will reach from the Sine of 45 deg. unto 60 deg. *fere*, the Angle of Inclination between the Meridian and the Plane.

2. To find the Substiles distance from the Meridian or hour of 12, O R.

As the Sine of 90 deg. ———————— 1000000
To the Co-sine of P O R, 59 deg. 59 min. ———————— 969918
So is the Tangent P O 16. 14 ———————— 946412
To the Tang. of the Substiles dist. from 12 O R 8 deg. 17 min. ———————— 916330

By the Gunter. Extend the Compasses from the Sine of 90 deg. to the Co-sine of 59 deg. 59 min. the same distance will reach from the Tangent of 16. 14, to the Tangent of the Substile from the Meridian 8 deg. 17 min.

3. To find the Elevation of the Pole above the Plane or Stiles height.

As the Sine of 90 deg. ———————— 1000000
To the Sine of P O 16 14 ———————— 944646
So is the Sine of P O R 59 deg. 59 min. ———————— 993746
To the Sine of P R the Stiles height above the Plane 14. 1 ———————— 938392

Or, Extend the Compasses from the sine of 90 deg. to the sine of 16 deg. 14 min. the same distance will reach from the sine of 59 deg. 59 min. to the sine 14 deg. 1 m. the Stiles height.

4. To

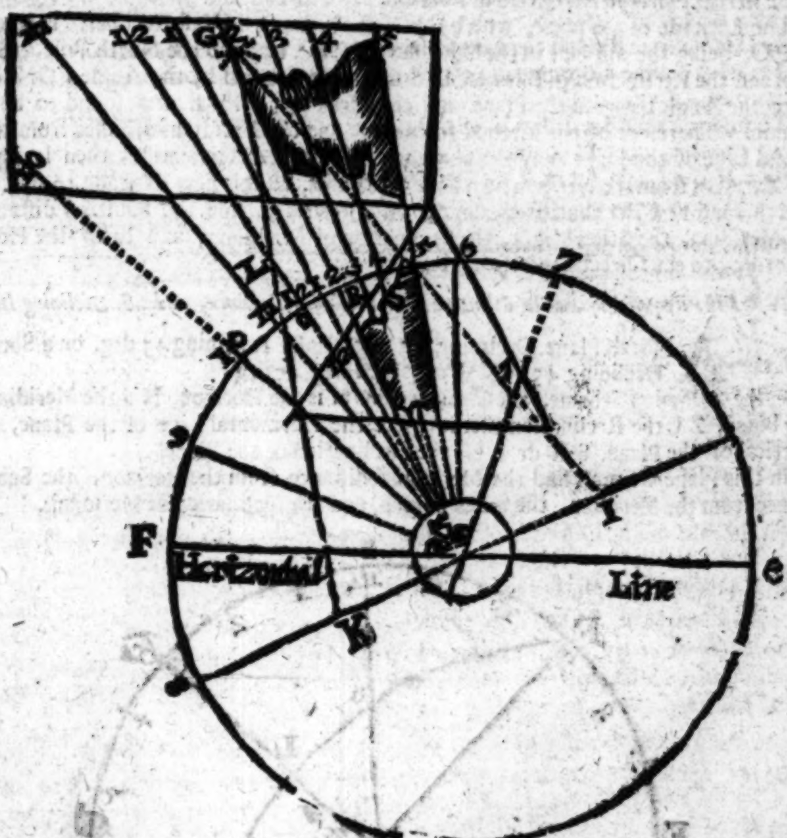
4. To find the Inclination of Meridians.

As the Sine of P O 16. 14	944646
To the Sine of 90 deg.	1000000
So is the Sine of the Substile distance 8 deg. 17.	915857
To the Inclination of Meridians 31 deg. 1 min.	971211

Extend the Compasses from the Sine of 16 deg. 14 min. to the Sine of 90 deg. the same Extent will reach from the Sine of the Substiles distance 8 deg. 7 min. to the Sine of the Inclination of both Meridians 31 deg. which is 2 hours 4 min.

Having got these four Requisites, *viz.*

1. The distance between the Horizon and the Meridian or hour of 12, 54 deg. 45 min.
2. The Substile distance from the Meridian of the Place O R 8 deg. 17 min.
3. The height of the Pole above the Plane or Stiles height P R 14 deg. 1 min.
4. The Inclination of Meridians 31 deg. 1 min. then proceed to delineate the Dial thus,



First, draw the Horizontal Line F e, and with the Chord of 60 deg. sweep the Circle F O R e; then take off the Chord of 54 deg. 45 min. the distance between the Horizon and the Meridian, and lay it from F to O; Then then take off the Chords 8 deg. 17 min. the Substiles distance, and lay it from O to R; then from the Center draw the hour of 12 and the Substile; and cross the Substile at right Angles with the Line I K; then take off the Stiles height 14 deg. 1 min. from the Line of Latitudes, and lay it both ways from C to K and I, then take off the whole Line of 6 hours, and from K toward G, and from I toward G, strike the two occult Arches; and draw the Lines K G and I G; then extend the Compasses from G to the Meridian Line at L, and apply that distance to the Line of six hours, and you will find it to be 2 hours 4 min. which is the Inclination of Meridians as before; Then lay that distance from I toward G, for the hour of 6, and take (as before directed) 1 hour, 4 min. and lay it off in the same manner from G toward K, and from I toward G; and the like

like do with 3 hours 4 min. 4 hours 4 min. and 5 hours 4 min. Then draw the Hour lines in your Plane, whether it be a Triangle, Circle, or Square, or what ſhape ſoever; and lay off the height of your Stile 14 deg. 1 min. by the Line of Chords, and draw it from the Center, and ſo fit it to your Plane, as you may ſee in the Figure, and your Dial is done.

Another way to delineate Reclining or Inclining Decliners.

YOu have ſeen how Eaſt and Weſt Reclining Dials are to be made; and how they fall out to be Circles of Poſition.

I will ſhew you how all reclining Dials may be reduced to Eaſt or Weſt Recliners, for ſome other Latitude, and the hours drawn by the ſame Method and Scheme.

Example. A South Plane declining Weſt 45 deg. Reclining 45 deg.

The Circles of Poſition, as have been ſhewed, do all croſs one another in the North and South Points of the Horizon. Now therefore by the Point O, in the Scheme before mentioned where the Plane cuts our Meridian, draw a new Horizon, as O B Q C, and then your Plane in that Horizon is a Circle of Poſition.

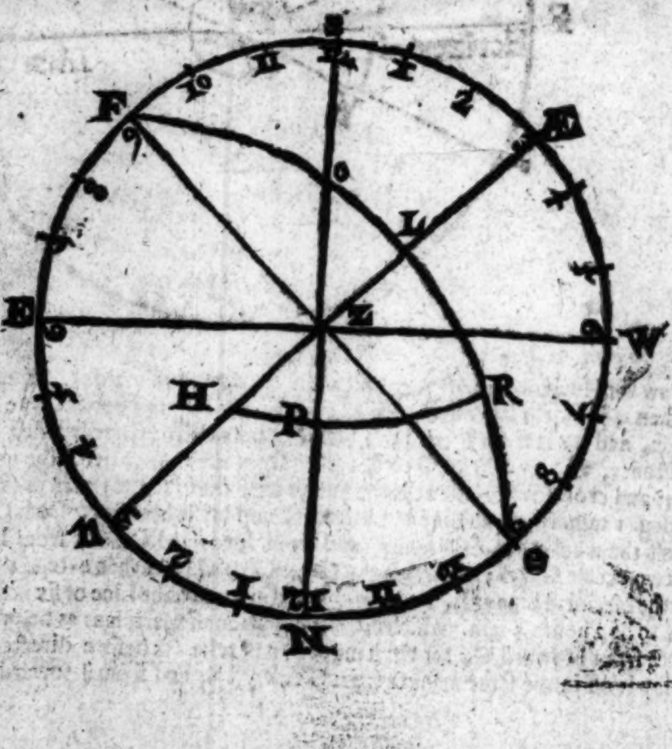
The Latitude of the place, where this Plane becomes a Weſt Recliner, is repreſented by P O, being the diſtance in the Meridian from the Plane to the North Pole, 16 deg. 14 min. and the Reclination in this new Latitude is repreſented by the Angle F O N, or P O R, being the Angle between the Plane and the Meridian, which was found to be 59 deg. 59 min. Therefore by the Method foregoing, find the Meridians diſtance from the Horizontal Line of the Plane, and the new Latitude and new Reclination, then laying of the the Meridian from the Horizon by a Line of Chords, to this new Latitude 16 deg. 14 min. North, and new Reclination 59 deg. 59 min. Weſterly, find the Subſtiles diſtance from the Meridian, the Stiles height, the Inclination of Meridians, and draw the Hour-lines, according to the Directions before given.

To find the Requiſites, and to delineate a N. Declining Recliner, and a S. Declining Incliner.

Example. A North Plane Declining 45 deg. Eaſt, Reclining 45 deg. or a South Plane Declining 45 deg. Weſt, Inclining 45 deg.

In the following Scheme, the Circle E S W N is the Horizon, N S the Meridian, F L e the Plane, Z L the Reclination thereof, F e the Horizontal Line of the Plane, Æ N the Vertical of the Plane, S Æ or n N the Declination of the Plane.

In this Plane we muſt find the Meridians diſtance from the Horizon, the Subſtiles diſtance from the Meridian, the Stiles height, and the Inclination of Meridians.



3. To

1. To find the distance of the Meridian or hour of 12 from the Horizon.

As the Sine of 90 ——————————————— 1000000
To the Co-sine of the Reclination 45 deg. ——————————— 984948
So is the Tangent of Declination 45 deg. ——————————— 1000000
To the Tangent Complement of F O 54 deg. 45 min. ——————— 984948
The Meridians distance from the Horizon.

By the Gunter. Extend the Compasses from the Sine of 90 to the Sine of 45; the same Extent will reach from the Tangent of 45 deg. to the Tangent of 35 deg. 15 min. which subtracted from 90 deg. there remains 54 deg. 45 min.

To find the Substiles distance from the Meridian O R, first find S O the distance in the Meridian between the Horizon and the Plane; secondly, S O F equal to P O R the Angle between the Plane and the Meridian.

To find the Arch of the Meridian between the Horizon and the Plane S O, thus:

As the Sine of 90 ——————————————— 1000000
Is to the Sine of the Arch of the Plane between the Horizon and Meridian F O 54 45 ——————————— } 991203
So the Sine of Reclination 45 ——————————— 984948
To the Sine of the Arch of the Meridian between the Horizon and Plane S O 35 deg. 16 min. } 976151

By the Gunter. Extend the Compasses from the Sine of 90, to the Sine of 54 deg. 45 min. the same Extent will reach from the Sine of 45 deg. to the Sine of S O 35 deg. 16 min. which 35 deg. 16 min. taken out of 90 deg. there remains O Z 54 deg. 44 min. the Arch of the Meridian between the Zenith and the Plane; which being added to the Complement of the Latitude Z P 38 deg. 30 min. it makes P O 93 deg. 14 min. the Arch of the Meridian between the Pole and the Plane, then for the Angle between the Meridian and the Plane F O S, or P O R.

As the Sine of the Arch F O 54 deg. 45 min. ——————————— 991203
Is to the Radius ——————————————— 1000000
So is the Co-sine of the Declination F S 45 deg. ——————— 984948
To the Sine of the Angle F O S 59 deg. 59 min. ——————— 993745

By Gunter's Rule. Extend the Compasses from the Sine of 54 deg. 45 min. to the Sine of 90 deg. the same Extent will reach from the Sine of 45 deg. to the Sine of 59 deg. 59 min. the Angle between the Meridian and the Plane.

2. To find the Substiles distance O R.

As the Sine of the Angle at R 90 deg. ——————————— 1000000
To the Co-sine of P O R 59 deg. 59 min. ——————————— 969918
So is the Tangent of the Sine P O 93 deg. 14 min. ——————— 1124801
To the Tangent of the Substile O R 96 deg. 27 min. ——————— 1094719

By the Gunter. Extend the Compasses from the Sine of 90 deg. to the sine of 30 deg. 1 min. the same Extent will reach from the Tangent of 86 deg. 46 min. to the Tangent of 83 deg. 33 min. whose Compl. to 180 deg. is 96 deg. 27 min.

3. For the Height of the Pole above the Plane, or Stiles height.

As the Radius ——————————————— 1000000
To the Sine of P O 93 deg. 14 min. ——————————— 999931
So is the Sine of P O R 59 deg. 59 min. ——————————— 993746
To the Sine of the Stiles height P R 59 deg. 49 min. ——————— 993677

4. To find the Inclination of Meridians O P R.

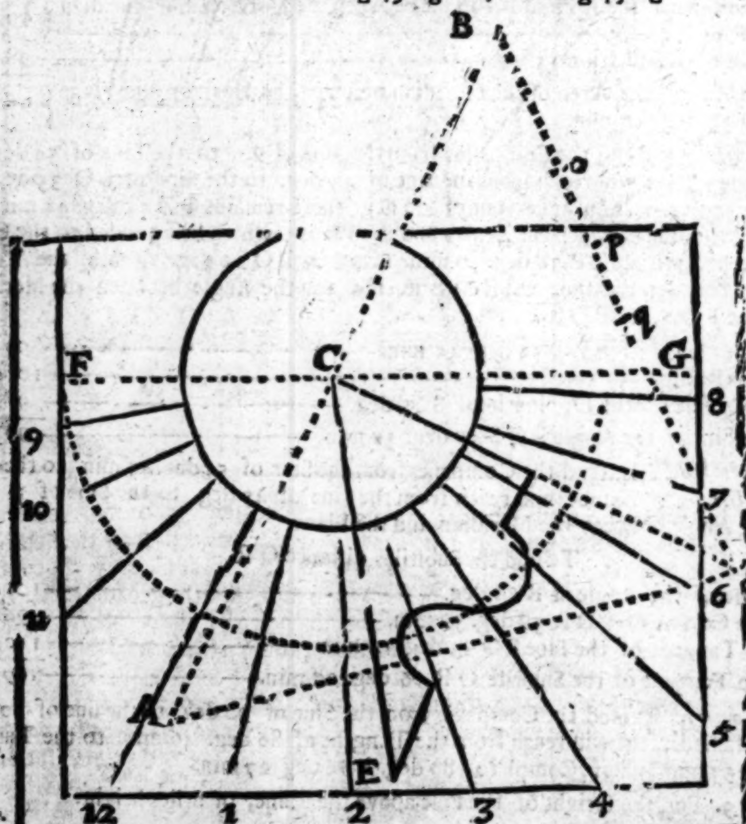
As the Sine of P O 93 deg. 14 min. ——————————— 999931
To the Radius ——————————————— 1000000
So is the Sine of O R the Substiles distance 96 deg. 27 min. ——— 999724
To the Sine of O P R the Inclinat. of Merid. 95 deg. 35 min. ——— 999793
Which 95 deg. 35 min. reduced to time make 6 hours, 22 min.

Having found the distance of the hour of 12 from the Horizon 54 deg. 45 min. the Substiles distance from the hour of 12, 96 deg. 27 min. the Stiles height 59 deg. 49 min. and

and the Inclination of Meridians 95 deg. 35 min. or 6 hours 22 min. proceed to delineate the South-west Incliner, by the Directions given as before, or briefly thus:

Set off the hour of 12 from the Horizon F G and the Substile C D from the hour of 12, and the Stile C E from the Substile by a Line of Chords, cross the Substile at right Angles with the Line A C B, and laying off the Lines height (by the Line of Latitudes) from C to A and B, drawing D B and D A from those two Points A and B, with the distance of six hours intersect the Substile in the Point D. The Inclination of Meridians being 6 hours, 22 min. lay off 5 hours 22 min. and 4 hours 22 min. (by the Line of 6 hours) from D towards A for the hours of 1 and 2, and the same distances from B towards D, for the hours of 7 and 8; likewise 3 hours 22 min. 2 hours 22 min. 1 hour 22 min. from D for the hours of 3, 4, and 5, and from B for the Points o, p, and q; and lastly 22 min. from D for the hour of 6. Note, the Points o, p, and q are to draw the hours of 9, 10, and 11 in the forenoon, on the other side the Center C. The hours proper for this Plane are from 9 in the morning to 8 at night.

A South Plane Declining 45 deg. West Inclining 45 deg.



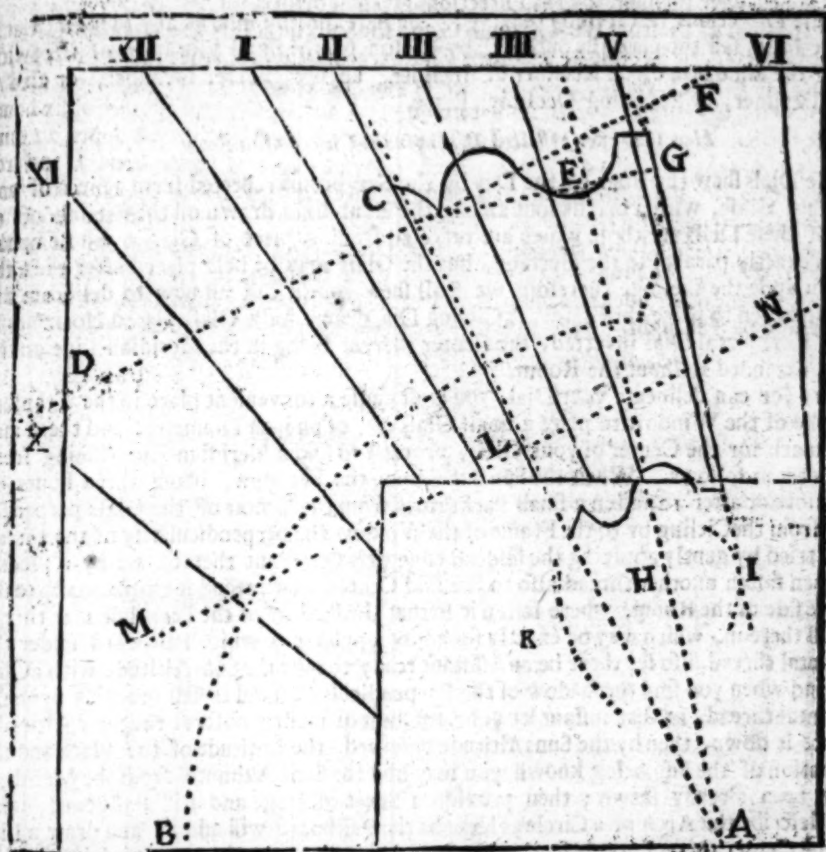
To delineate such Planes wherein the Stiles height is small, not exceeding 15 deg.

In these Planes the hour-lines fall so near the Substile, that they make the Dial unhandsom, and almost useless, and therefore we commonly inlarge them, by removing the Center of the hour-lines beyond the Dial Plane, drawing them by two Contingent Lines, by the help of Lines on the Mathematical Scale, called the greater and lesser Pole; as follows.

For an Example, we will take the South Plane which declines 45 deg. Westerly, and reclines 45 deg. In this Plane the Substiles distance from the Horizon is 63 deg. 02 min. for the Meridians distance from the Horizon was found to be 54 deg. 45 min. and the distance from the Meridian to the Substile 8 deg. 17 min. the same way, which added to 54 deg. 45 min. makes 63 deg. 02 min. the Stiles height is 14 deg. 01 min. and the Inclination of Meridians in time 2 hours 04 min. Now proceed to draw the Hour-lines on the Plane thus.

A

A South-west Plane Declining 45 deg. and Reclining 45 deg.



From the Horizontal Line A B set off the Substiles distance 63 deg. 02 min. and from the Substile the Stiles height 14 deg. 10 min. by the Line of Chords, and draw the Substile A C and the Stile A E, and from a convenient Point in the Substile as at C, draw the contingent line D F at right Angles therewith; then from the Line called the greater Pole, take the distance of 3 hours, and setting your Compasses at C, describe the occult Arch at G, and from the Point C draw the Line C E G Perpendicular to the Stile A E in the Point E, and with the Distance E G, upon the Point H, describe the occult Arch at I, and by the Arches G and I draw the toucht line I G for the inlarged Stile: Then take the distance of 3 hours from the Line called the lesser Pole, and setting your Compasses at I describe the Arch at K, a Ruler laid from C to touch the Arch K, shall cross the Substile in the Point L, from which Point draw the Contingent Line M N at right Angle with the Substile. Take the Inclination of Meridians 2 hours 04 min. of the greater Pole, and place it on the greater Contingent Line, from C towards D, and 2 hours 04 min. from the lesser Pole, and place it on the lesser Contingent Line, from L towards M, and by these two Points on the two Contingent Lines draw the hour of 12; likewise place 3 hours 04 min. of the greater Pole on the greater Contingent Line, and the same distance of the lesser Pole on the lesser Contingent, for the hour of 11, also 4 hours 04 min. of the greater Pole, on the greater Contingent Line from C towards D, and 4 hours 04 min. of the lesser Pole on the lesser Contingent Line from L toward M for the hour of 10; likewise the distances of 1 hour 04 min. and 0 hour 4 min. from the greater and lesser Pole, on the greater and lesser Contingent Lines, from C and L for the hours of 1 and 2. Subtract 4 min. from 1 hour or 60 min. and the remainder 56 min. take from the greater, and also from the lesser Pole, and place it on the greater and lesser Contingent Lines, from C and L towards F and N for the hour of 3; after the same manner place the distances of 1 hour 56 min. of 2 hours 56 min. and of 3 hours 56 min. taken from the greater and lesser Pole, or the greater and lesser Contingent Lines for the hours of 4, 5, and 6; and by these

these Points on both Contingent Lines draw your Hour-lines, and finish your Stile and Dial.

If these Directions be carefully observed, you may thereby inlarge any Plane in which the Hour-Lines fall too near the Substile, by reason of the small Elevation of the Stile; whether the same be a direct Recliner or Incliner, an upright for Decliner, or an Inclining Decliner, or Reclining Declining Plane.

How to draw a reflected Dial upon the Cieling of a Room.

THese Dials shew the Hour of the Day by the Sun-beams reflected from a piece of polished Glass, with a bright spot among the Hour-lines drawn on the Cieling. The easiest of these Dials are those which are reflected from a piece of Glass, whose upper Plane is exactly parallel to the Horizon, but the Glass may be best placed after the Dial is drawn upon the Cieling, therefore we shall shew you first of all how to delineate the same, and then to place the Glass. A Cieling Dial drawn for a Glass placed Horizontally is an Horizontal Dial inverted, the Center thereof being in the Meridian-Line on the Cieling extended without the Room.

Before you can delineate your Dial, you must chuse a convenient place in the Transum or Stroke of the Window to place a small Glass of $\frac{1}{4}$ of an inch Diameter, and there making a mark for the Center of your Glass, proceed to find a Meridian-Line issuing from that Center as follows. When the Sun shines upon the Window, being three hours or more before or after 12, fasten a small Packthread from the Center of the Glass perpendicularly from the Cieling or to the Frame of the Window, the perpendicularity of the thread may be tried by gently applying the fiducial edge of a Quadrant thereto, or by a plumbline, then fasten another thread also to the said Center, and extend it Horizontally to the opposite side of the Room, where fasten it so that the shadow of the Perpendicular thread may fall thereon, which may be exactly found by applying a white Pastboard under the Horizontal thread, also let there be an Assistant ready to take the Suns Altitude with a Quadrant, and when you find the shadow of the Perpendicular thread to fall precisely upon the Horizontal thread, at that instant let your Assistant diligently observe the Suns Altitude, and note it down, then by the Suns Altitude observed, the Latitude of the Place and the Declination of the Sun being known, you may find the Suns Azimuth from the Meridian, as hath been already shewn; then provide a Sheet of large and stiff Pastboard, upon which describe the Arch of a Circle as large as the Pastboard will admit, and draw a Line from the Center thereof, representing the Suns Azimuth at the time you took it, then by a Sector, having a Line of Chords issuing from the Center, (fitting the Radius of the Arch into the Chord of 60 deg.) lay the Chord of the Suns Azimuth from the Meridian according to its proper Coast, on the Arch drawn on the Pastboarst, from the Line drawn thereon, where the Compasses rest, through that point draw a Line from the Center which represents the Meridian Line. Lay this Pastboard so, that the Center of the Circle drawn thereon may agreee with the Center of the Glass, and that the Line drawn on the Pastboard representing the Suns Azimuth, be placed under the Horizontal thread strained in the Room, and exactly agreeing therewith; this done, fasten the Pastboard to the Transum of the Window Horizontally with small Nails, then loose the Horizontal thread, and bring it exactly over the Meridian Line drawn on the Pastboard, and fasten it so to the opposite side of the Room Horizontally, and so it becomes a Meridian Line; and this Meridian Line may be transferred to the Ceiling by a Plumbline applied from several points in the Ceiling, so as to touch this thread representing the Meridian, a Line drawn by these Points is a Meridian Line on the Ceiling, as A B C K in the following Scheme. Now to draw the Hour-lines; extend a thread from the Center of the Glass at D, to the Point C in the Meridian on the Ceiling, so that the Line C D may make an Angle of 38 deg. $\frac{1}{2}$ with the Meridian, which may be found by applying the fiducial edge of a Quadrant thereto; from the Point C draw C P at right Angle with the Meridian; then measure C D, which we will suppose to be 63 Inches $\frac{1}{2}$, then to find the distances C E, C F, C G, &c. upon the Line C P for drawing the Hour-lines proceed thus, say,

Vide Astronomical Prob. Book 6.

As Radius	And,	As Radus
To C D $63\frac{1}{2}$.		To C D $63\frac{1}{2}$.
So is Tang. 15 deg. for 1 hour		So is Tang. 33 deg. for 2 hours
To C E $16\frac{2}{3}$.		To C F $38\frac{1}{2}$.

And

And so for C G, C H, *&c.* as in the Table following the Scheme. Then draw another Line as K O parallel to C P, and suppose the distance C K to be 47 Inches; then to find the distances K L, K M, K N, *&c.* first find A K, thus.

As the Sine of D A C 51 deg. 30 min.
to C D 63 1/10 Inches
So is Radius
to A C 81 Inches

Which added to C K 47 Inches makes A K 128 Inches.

Then find K S which is parallel to C D, thus,

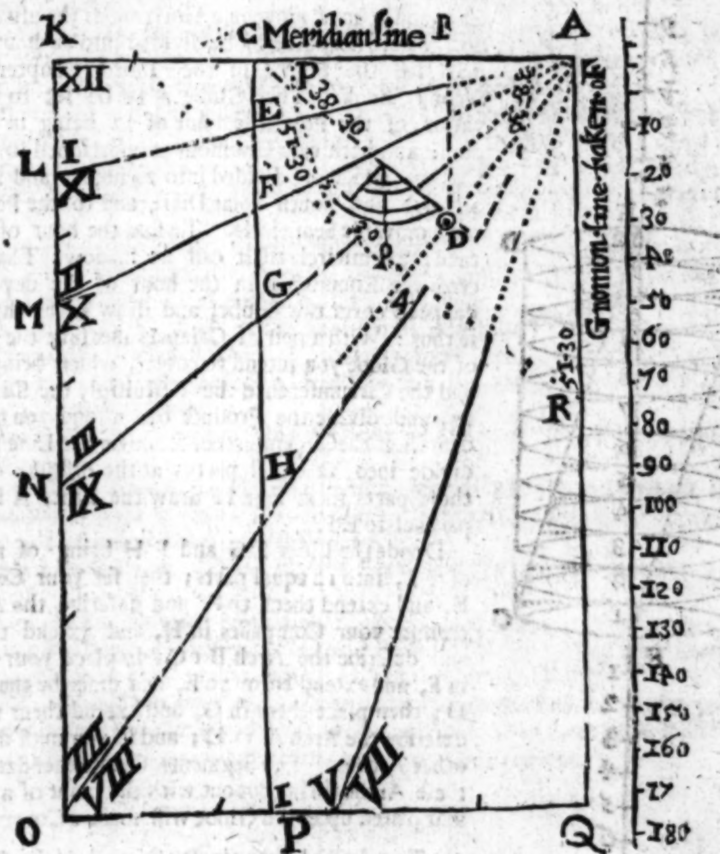
As Radius
to A K 128 Inches
So is Sine K A S 51 d. 30 m.
to K S 101 Inches

Then to find the distances K L, K M, K N, *&c.* proceed thus

Say,
As Radius
to K S 101 Inches
So is Tang. 15 deg. for 1 hour
to K L 26 Inches 8/10,

And
As Radius
to K L 101 Inches
So is Tang. 30 deg. for 2 hours
to K M 57 Inches 9/10.

And after the same manner find K N, K O, *&c.* as in the aforesaid Table.



The Table.

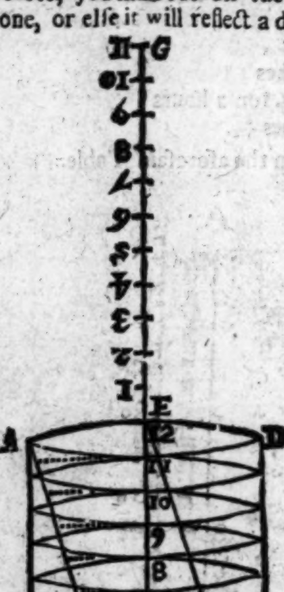
		Inches	par.			Inches	par.
C	E	16	9	K	L	26	8
C	F	38	5	K	M	57	9
C	G	63	3	K	N	101	0
C	H	109	6	K	O	173	6
C	I	136	5	K	P	373	6

Note, You must extend the Lines C P and K O on both sides of the Meridian A K as far as you can, and also set off the distances C E, C F, C G, *&c.* and K L, K M, K O, *&c.* on both sides the said Meridian, and by those Points draw the Hour-lines of 11, 10, 9, *&c.* on the West side

side of the Meridian, and the hours of 1, 2, 3, &c. on the East side of the Meridian, and finish your Dial.

To place the Glass Horizontal, take these Directions: When you find it to be near 12 at Noon, by some Quadrant or Sun-Dial, fix the Glass in the hole appointed for it with some Putty, as near Horizontal as you can, then with a Quadrant take the Altitude of the Sun, and observe the place where the Spot reflected from the Glass falls on the Ceiling, and make a mark there, then extend a thread from the Center of the Glass to the mark on the Ceiling, and apply the fiducial edge of the Quadrant thereto, and thereby find what Angle the said thread makes with the Horizon, which if it be the same with the Suns Altitude, the Glass is well placed, but if it differ therefrom, then you must remove the Glass according to Discretion, till it agree with the Altitude of the Sun, which you must examine by several trials, and so fix it with Putty or Cement.

Note, you must rub off the Pollish of the Glass on the backside thereof with a Pumice Stone, or else it will reflect a double Spot.



To make an Universal Dial on a Globe; and to cover it if required.

A *Globe saith Euclid, is made by the Rotation of a Semicircle, keeping the Diameter fixed.* This Dial, if Universal, will want the aid of a Magnetical Needle to set it, and it must move in a Horizon, as the usual Globes do; whose Æquator let be divided into 24 hours. You may see the Figure in the Third Chapter of the Second Book. This Globe is to be set to the Elevation of the Pole, the hour of 12 being in the Meridian, and hath two Gnomons proportioned to the Polar Circles, which are divided into 24 hours, and serves for a North and South Polar Dial; and to the Poles is fitted a movable Semicircle. To find the hour of the Day, turn the Semicircle till it cast no shadow: Then doth it cross the Equinoctial in the hour of the day. If you desire to cover the Globe, and draw Lines thereon, do it thus: With a pair of Calapers measure the Diameter of the Globe you intend to cover; which being known, find the Circumference thus: Multiply the Diameter by 22, and divide the Product by 7, and you have your desire. Let the Circumference found be the Line E F, which divide into 12 equal parts; at the distance of three of those parts from E and F draw the Lines A B and C D parallel to E F.

Divide the Lines E G and F H being of the length of F E, into 12 equal parts; then set your Compasses at E, and extend them to F, and describe the Arch B C, then set your Compasses in H, and extend them to 1, and describe the Arch B 1 C; so place your Compasses in F, and extend them to E, and describe the Arch A E D; then place them in G, and extend them to 11, and describe the Arch A 11 D; and so you must describe the other Arches. The Segments Comprehenders between these Arches being cut out with the point of a Pen-knife, and pasted upon the Globe will make a Cover for it.

To paint and finish the Dials, ready to be set up in their Places.

For to fasten the Stile into the Plane, if it be of Wood, you must have a small thin Chizel, Gouge, and Gimblet, to let in the Stile, be it round as a rod of Iron, or a piece of Brass, let in with a foot an inch and half, more or less, as you see convenient; and in the Wood make such little Mortises as just the breadth and length of the foot of the Stile; and if it comes thorow, to clinch on the other side, then it is fast.

If

If it is in Freestone, your Dial drawn first in Paper, lay it upon the Plane as it should be; then cut out the Substile-line as near its breadth as you can, and only leave so much as will just hold it together. The Paper laid as before on the Plane, with a Black Lead Pensil, or such like, draw the Substile-line where it stood in the Paper, and with a small Chizel make such Mortises in that Line as are answerable to the foot of the Stile; and crook his foot, and put it into its place; then with a small Ladle and some Lead melted, put the Stile perpendicular with the Plane, and pour in the Lead into the Mortise until it is full; and when it is cold, then with a blunt Chizel harden the Lead in on each side of the Stile or Gnomon: And if the Mortise should be too wide, or broken, and not even with the Plane, then wet some flower of Alabaster, (as you may have it fit for that purpose at any Masons) and as soon as it is wet make a Plaster, and so smooth it; and spread it even and plain, and it is presently dry. Now have you the Stile fast.

To paint them, you must first Prime them: The Prime is made thus. Take an equal quantity of Bole-Armoniack and Red Lead, well ground together with Linseed-Oyl, and well rubed in with a Brush or Pensil into the Plane; that being dry, for the outside colour, it is White Lead or Ceruse well ground together with Linseed-Oyl. Buy the White Lead and grind it to a Powder, and put it into Water until it become as thick as Pap, and let it dry; then it is for your use to grind with Oyl.

For the Hour-lines a Vermilion, and a part Red Lead, well ground together with Linseed-Oyl, with a small quantity of Oyl of Spike, or Turpentine that will dure, and make the Lines shine.

For a Gold Border, rub the Border well with the white Ceruse; be sure it be very thick in the Border: Then with Blue Smalts strew very thick the Border while it is wet, and when it is dry, wing that which is loose off, and save it in a Paper.

Take Red Lead and White Lead, as much Red Lead again as White, or Yellow Oker, well ground with Oyl of Spike or Turpentine; this is the Sise: Then draw with that the Figure you would have in Gold, and when it is so dry that it will not come off on your Fingers by a slight touch, lay on the Gold; and when it is thorowly dry, wing it off.

How to make a good Black, to shadow or make Figures. Grind well with Linseed-oyl Lamb-black, with some Verdigrease, and that is a firm Black. The like you may do with all other Colours, as you fancy for such Work.

A Receipt for Red Ink. First, Steep one Penny-worth of Brazeel-Wood all night in Urine; then boil it well and strain it; then bruse two penny-worth of Cochineel, and boil it, and put in it the bigness of a Hens Egg of Roch-Allom, that brings it to a colour, and then it is for your turn.

To paint Freestone, wash the Stone with oyl, and then all the Colours before may be used, as directed.

How to cleanse a Picture. Take Blue Smalts, temper it in Water, and rub the Picture with it, and after wipe it with a Linnen Cloth, which Cloth should be dipped in Beer, or otherwise with a dry Cloth and it is clean.

To cleanse a Gold Border. Wash it with Beer, and dry it, and then cleanse it with Linseed-oyl.

Masticous is a fine Yellow, ground with some Oyl of Spike or Turpentine.

Bice is a good Blue Colouring, to be ground with Linseed-oyl and Red-Lead.

And Spanish Brown will make a lasting Colour for Coarse Work.

To grind Gold to Write and Paint. Take as many Leaves of Gold as you please, Honey three or four drops; mix and grind these, and keep it in some Bone Vessel. If you will write with it, add some Gum-water, and it will be excellent.

All things pass on: Those Creatures which are made,
Fail, and by Time's assiduate motion fade.
Much like the Running Stream, which cannot stay;
No more can the light Hours that post away.
But as one Billow, hast'ning to the Shore,
Impels another, and still that before
Is by the following driv'n; so we conclude
Of Time, it so flies, and is so pursu'd.
The Hours are always new; and what hath been
Is never more to be perceiv'd or seen:
That daily grows, which had before no ground;
And Minutes, past once, never more are found.
The fretting Age deceives, and stealing glides;
And the swift Year on loose-reign'd Horses rides.

A

A Summary of such Penalties and Forfeitures as are limited and appointed by several Acts of Parliament *relating to the Customs and Navigation.*

First, ALL manner of Goods imported into his Majesty's Plantations, or exported out of his Majesty's Plantations, in Foreign Shipping, both Ship and Goods are forfeited. *Vide Statute of Navigation*, 12 *Caroli* 2. 18.

Secondly, All Goods that are of the growth of *Asia*, *Africa*, and *America*, imported in Foreign Shipping are forfeited, *per id. Stat.*

Thirdly, All Goods of the growth, production, and Manufacture of *Asia*, *Africa*, and *America*, shall be imported from the place of their growth, production, or manufacture; otherwise both Ship and Goods are forfeited, *per id. Stat.*

Except the Goods of the *Spanish* Plantations may be brought from *Spain*, and the Goods of the *Portugal* Plantations may be brought from *Portugal*, and *East India* Commodities may be brought from any Port on the Southward or Eastward of *Cape Bona Speranza*, and the Commodities of the *Levant* Seas may be brought from any Port within the *Straights*; provided that all these Goods may be imported in *English* Shipping, otherwise both Ship and Goods are forfeited, *per id. Stat.*

Fourthly, All Goods of Foreign growth, production, or manufacture, shall be imported from the place of their growth, production, or manufacture, or from such place where they are usually first Shipp'd for Transportion only, and only in *English* Ships, or in Ships truly belonging to such place where such Goods are lawful to be Shipp'd; otherwise both Ship and Goods are forfeited, *per id. Stat.*

Fifthly, All Goods carried from Port to Port (in *England*, *Ireland*, *Wales*, or *Berwick*) in Foreign Shipping, whereof the Owners or Part-owners are not all *English*, also the Master and three fourths of the Mariners, both Ship and Goods are forfeited, *per id Stat.*

Sixthly, All Goods of the growth, production, or manufacture of any of his Majesty's Plantations, shall be first landed in *England*, *Ireland*, *Wales*, or *Berwick*, before they can be Transported; otherwise both Ship and Goods are forfeited, *per id Stat.*

Seventhly, All manner of Wines, except Rhenish; all Spicery and Grocery, Tobacco, Pot-Ashes, Pitch, Tar, Rosin, Salt, Deal Boards, Fir Timber, or Olive-Oyl, that shall be imported from the *Netherlands* or *Germany*, are forfeited, as also the Ship in which they are imported, *Vide Stat.* 14 *Car.* 2. 11. intituled, *An Act to prevent Frauds*, &c. *in his Majesty's Customs.*

Eighthly, All fresh Herrings, fresh Cod or Haddock, Cole-fish or Gull-fish, that shall be imported into *England* or *Wales*, in Foreign Shipping, both Ship and Goods are forfeited. *Vide Stat.* 15 *Car.* 2. 5. intituled, *And Act for encouraging of Trade.*

Goods forfeited for being imported into England *or* Wales, *without any Penalty upon the Ship; these Goods being all English Manufactures.*

ALL manner of Tin and Pewter Manufactures made in Foreign Parts are forfeited, *Vide Stat.* 25 *Hen.* 8. 14.

Officers may search and seise Wares brought into the Realm contrary to the said Act, and none shall withstand the search of Brass, Tin, and Pewter, on the forfeit of five Pounds, *per id. Stat.*

Woollen Cloths, Woollen Caps, Ribons, Fringes of Silk and of Thread, Laces of Silk and of Thread, Silk Twine, Embroidered Laces of Silk or Gold, Saddles, Stirrops, or any Harness belonging to Saddles, Spurs, Bosses for Bridles, Andirons, Gridirons, any manner of Locks, Hammers, Pincers, Fire-tongs, Dripping-pans, Dice, Tennis-balls, Points, Purses, Girdles, Gloves, Harness for Girdles, Iron, Latten, Steel, Tin, or Alchymy, or any Wrought, or any Tawed Leather, any Tawed Furs, Biskin Shoos, Galloshes, or Cork, Knives, Daggers, Wood-knives, Bodkins, Sheers, for Taylors, Scissors, Razors, Chess-men, Playing Cards, Combs, Pattens, Pack-needles, any painted Wares, Forsers, Caskets, Rings of Copper or of Latten, gilt Chafingdishes, Hanging Candlesticks, Caffing Balls, Sacring Bells, Rings for Curtains, Ladles, Scummers, counterfeit Basons, Ewers, Hats, and Brushes, Cards for Wooll, black Iron, Thread called Iron Wire, or whited Wire, are forfeited if any such be imported into *England* or *Wales*. *Vide Stat.* 4 *Edw.* 4.

All

All Iron-Wire, Card-wire, or Wooll-cards, that shall be imported into *England* or *Wales*, are forfeited. *per Stat.* 39 *Eliz.* 14. 14 *Car.* 2. 19.

All manner of Girdles, Harness for Girdles, Points, Leather, Laces, Purses, Pouches, Pins, Gloves, Knives, Hangers, Taylors Sheers, Scissors, Andirons, Cobbards, Tongs, Fire-locks, Gridirons, Stock-locks, Keys, Hinges and Garnets, Spurs, painted Glasses, painted Papers, painted Forcers, painted Images, painted Cloaths, beaten Gold or Silver wrought in Papers for Painters, Saddles, Saddle-trees, Horse-Harness, Boots, Bits, Stirrops, Chains, Buckles, Latten-Nails with Iron Shanks, Curvets, Hanging-candlesticks, Holy-water, Stops, Chafing-dishes, Hanging Lavers, Curtain-Rings, Cards for Wool, Roan Cards, Sheers, Buckles for Shoos, Broaches for Spits, Belts, Hawk-bells, Tin and Leaden Spoons, Wire of Latten and Iron, Candlesticks, Grates, Horns for Lanthorns, or any of these, being imported into *England*, are forfeited, or the value thereof, betwixt the King and the Prosecuter. These may be sued for in any Corporation where they are. *Vide Stat.* 1 *R.* 3. 12.

All Girdles, Harness for Girdles, Rapiers, Daggers, Knives, Hilts, Pummels, Lockets, Blades, Handles, Scabbards, Sheaths for Knives, Saddles, Horse-Harness, Stirrops, Bits, Gloves, or Points, Leather, Laces, or Pins, that shall be imported into *England* or *Wales*, shall be forfeit. 5 *Eliz.* 7.

All manner of Silk wrought by it self, or with any other Stuff, in any place out of the Realm, Ribbons, Laces, Girdles, Corses called Corses of Tissue, or Points, shall be forfeited, *per Stat.* 19 *Hen.* 7. 21.

All Foreign Bone-lace, Cut-work, Fringe, Embroidery, Bandstrings, Buttons, or Needle-work, made of Silk or Thread, or either of them, being imported into *England*, *Wales*, or *Berwick*, shall be forfeited, besides the forfeiture of 100 pound. 14 *Car.* 2. 13.

All manner of Woollen Cloth that shall be Imported into *England*, *Ireland*, or *Wales*, from beyond the Sea, shall be forfeited. *Vide Stat.* 2 *Edw.* 3. 3. and 4 *Edw.* 4. 1.

In what Cases Goods are forfeited for undue Shipping or Landing.

ALL Goods that shall be Shipped or Landed before the Custom paid or agreed for in the Custom-house, are forfeited. *Vide Stat.* 12 *Car.* 2. 4. intituled, *The Act for the Tonnage and Poundage.*

All Goods that shall be Shipped or Landed, or put into any other Vessel to be Shipped or Landed, at any unlawful time or place, are forfeit, or the valne of them. 1 *Eliz.* 2. and 14 *Car.* 2. 11.

All Goods that shall be put into any Lighter, Boat, or any other Vessel, to be Shipped or Landed, without Warrant from the Custom-house and the presence of one or more Custom-house Officers, are forfeited, as also the Lighter or other Vessel in which they are found to be Shipped or Landed. *Vide Stat.* 14 *Car.* 2. 11.

If any Master of Ship, Purser, Boatswain, or other Mariner, knowing or consenting to the discharge of Goods inward bound, without Warrant from the Custom-house or the presence of one or more Custom-house Officer, shall forfeit the value of the said Goods so unshipped. *Vide Stat.* 14 *Car.* 2. 11.

Every Customer, Collector, and Comptroller, that doth conceal his Majesties Customs, being duly Entred, shall forfeit treble the value thereof, *per Stat.* 3 *H.* 6. 3.

If any Goods having paid Custom at the Importation, and ought to have allowance at the Exportation; If the Merchant Ship out less in quantity than is expressed in his Certificate, shall be forfeited, or the value of them. 14 *Car.* 2. 11.

If the said Goods be Landed again in *England*, *Wales*, or *Berwick*, except they be made known in the Custom-house, shall be forfeit, *per id. Stat.*

If any Goods be put on board a Ship to be carried from Port to Port, without Warrant from the Custom-house, all such Goods shall be forfeit, *per id. Stat.*

If the true Content of Quantity and Quality be not mentioned in the Certificate, under the Customers hand in the Port where they are Shipped first to pass for another Port, all such Goods not certified or discharged before the said Certificate delivered, and the Goods viewed, shall be forfeit, *per Stat.* 3 *H.* 7. 7.

Quere, Whether this Statute be in force or not?

All manner of Goods, Wares, or Merchandize, that shall be Exported, and escape undiscovered unto the Offices of the Customs, the Owner or Proprietor shall forfeit double the Value, according to the *Book of Rates*; Except for Coals, for which they shall forfeit double the Custom. *Vide Stat.* 14 *Car.* 2.

All Goods, Wares, and Merchandize, that shall pass by Land betwixt *England* and *Scotland*, shall pass by and through *Barwick* and *Carlisle*, and pay Custom at one of those Ports, otherwise be forfeited, *per Stat.* 14 *Car.* 2. 11.

In what Cases Ship and Goods are forfeited upon Exportation of Goods.

IF any Woman, or other person under the Age of twenty one years, except Ship-boys, Saylors, or Merchants Apprentices, or Factors, shall pass over the Sea, without Licence from the King, or six of the Privy Council, the Ship in which such Person shall so pass shall be forfeit. *Vide Sat.* 1 *Jac.* 4.

If any Person shall Transport, or Ship to be Transported, Leather, Tallow, or Raw Hides, to any place beyond the Sea, all such Goods shall be forfeit, as also the Ship wherein they are Exported. *Vide Stat.* 18 *Eliz.* 9.

If any Hoy or Plat cross the Seas beyond *Norway Eastward*, or *Caen* in *Normandy* Southward, they shall be forfeit. *Vide Stat.* 1 *Eliz.* 13. 5 *Eliz.* 5. 13 *Eliz.* 15.

If any Corn, or other Victual, be Transported, exceeding the Prices mentioned in the *Act for encouraging of Trade*; or if any Wood shall be transported, they shall forfeit the Vessel in which it shall be Exported, and also double the value of the Goods. *Vide Stat.* 1. 2 *Phil. & Mar.* 5. the Masters and Mariners all their Goods, and a years Imprisonment.

If any Goods of the growth, production, or manufacture of *Europe* be transported into his Majesties Plantations, except from *England*, and *English* built Shipping, both Ship and Goods, are forfeited. *Vide Stat.* 15 *Car.* 2. 5.

If the Master shall suffer any Goods to be Landed before a due Entry made within twenty four hours after arrival in the said Plantations, both Ship and Goods are forfeited. *per id. Stat.*

If any Ship shall set out to Fishing, or other Vessel shall set out for the West Country or *Iseland* Fishing, before the tenth day of *March* in any Year, such Vessel shall be forfeit. *Vide Stat.* 15 *Car.* 2. 14. intituled, *An Act for the Fishing Trade.*

If any Sheep or Woll, Woll-fells, Wooll-flocks, Mortlings, Shorlings, Yarn made of Wooll, Fullers-Earth, Fulling-Clay, shall be Exported, all such Goods are forfeit, as also the Ship wherein they are Exported. *Vide Stat.* 12. *Car.* 2. 32.

If any Silver or Gold be Exported without Licence, it shall be forfeited. *Vide Stat.* 5 *R.* 2. 2. & 9 *Edw.* 3. 1. & 2 *Hen.* 4. 5. & 2 *Hen.* 6. 6.

None but Merchant Strangers shall transport Woll, Wooll-fells, Leather, and Lead beyond the Seas, upon the forfeiture of the said Goods. *Vide Stat.* 27. *Ed.* 3. 3. 14 *Rich.* 2. 5.

If any Skin, tann'd or untann'd, of any Ox, Steer, Bull, Cow, or Calf (except Calve-skins of four pound weight a-piece, or under) and Sheeps-skins dressed without the Wooll of such Skins or Hides, which are for the Ships necessary Provision, shall pass out of *England* beyond the Seas, or into *Ireland* or *Scotland*, or the Islands belonging to *England*, shall be forfeited. *Vide Stat.* 14. *Car.* 2. 7.

If any of the Hides or Skins aforesaid, that shall be taken off of any Beast in any of the Islands belonging to *England*, except *Ireland*, shall be transported into any Place except *England*, the Offender shall forfeit double the value for every Offence, *per id. Stat.*

All manner of Ammunition may be prohibited at His Majesties Pleasure, 12 *Car.* 2. 4.

If any Sheep shall be Exported, the Offender shall forfeit 20 *s.* for every Sheep. *Vide* 12 *Car.* 2. 32.

If any Wooll, Wooll Fells, Wooll Flocks, Mortlings, Shorlings, Yarn made of Wooll, Fullers Earth, Fulling Clay, shall be shipped to be Exported, the Offender shall forfeit three Shillings for every pound weight.

If any Master of a Ship, or other Mariner, be knowing and consenting to the Exportation of the Goods aforesaid, he shall forfeit all his Goods and Chattels, *per id. Stat.*

These Offences are also made Felony *per Stat.* 13, 14. *Car.* 2. 18. except such Weather-sheep, Wooll, or Wooll-flocks, as are for necessary proportion for the Ships use.

If any Wooll, Wooll-flocks, or Yarn made of Wooll, shall be pressed with any Engine into any Sack, Pack, or other Wrapper, or shall put, press, or steeve Wooll or Woollen Yarn into any Pipe, Butt, or Hogshead, Chest, or other Cask or Vessel, or carry or lay any such Wooll, Wooll-flocks, or Yarn made of Wooll, near to the Sea, or any Navigable River, all such Wooll, Wooll-flocks, and Yarn made of Wooll, shall be forfeited. *Vide Stat.* 13, & 14 *Car.* 2. 18.

If any Wooll, Wooll-fells, Mortlings, Shorlings, Yarn made of Wooll, Wooll-flocks, Fullers-Earth, Fulling-clay, or Tobaccopipe-clay, being in any Pack, Sack, Bag, or Cask, shall be carried upon any Horse, Cart, or other Carriage, except in the day time, *viz.* from the first of *March* to the twenty ninth of *September* betwixt the hours of four in the Morning, and eight at Night, and from the twenty ninth of *September*, until the first of *March* between the hours of seven in the Morning, and five at Night, otherwise to be forfeited, *per id. Stat.*

If

If any Tobaccopipe-clay be Exported beyond the Sea, the Officer shall forfeit three Shillings for every pound weight, *per id. Stat.*

If any manner of Sheep-skins, Wooll-fells, Mortlings, Shorlings, or the Skins of any Stag, Buck, Hind, Doe, Goat, Fawn, or Kid, or the Pelts or Skins of any of them, or the Leather made of any of them, be put on board any Vessel to be Exported, they shall be forfeited, as also two Shillings six Pence for every Fell, Shorling, Mortling, Pelt or Skin, so shipped to be Exported. *Vide Stat.* 5 *Eliz.* 22.

All great Cattel, except of *Scotland*, that shall be imported into *England* or *Wales* betwixt the first of *July* and the twentieth of *September*, in any Year; and all great Cattel of *Scotland* that shall be brought in betwixt the twenty fourth of *August* and the twentieth of *December* in any Year, shall forfeit for every Head Forty Shillings; and for every Sheep brought in betwixt the one and twentieth of *August* and twentieth of *December*, ten Shillings *per Stat.* 15 *Car.* 2. 5.

If any Goods be entered in any other Mans Name than the true Owner and Proprietor, they shall be forfeit: And if the Officer conceal any offence in the said Act, he shall forfeit one hundred pounds. *Vide Stat.* 1 *Eliz.* 11.

If any Man, being free of the Prisage of Butlerage of Wine, shall Enter another Mans Wines in his Name, whereby the King loseth his Butlerage, all Wines so Entered are to forfeit double the value of the Customs thereof. *Vide* 1 *Hen.* 8. 5.

If any Man offend contrary to the *Stat.* 1 *Hen.* 8. 5. he shall forfeit all his Goods. *Vide Stat* 2, & 3 *Edw.* 6. 22.

If any Officer of the Custom shall suffer or give any Warrant for any Sugar, Tobacco, Ginger, Cotton-wooll, Indico, Speckle-wood, *Jamaico*-wood, Fustick, or any other Dying-wood, of the growth of any of his Majesty's Plantations, to be conveyed into any parts beyond the Seas, before they are Landed in *England* or *Wales*, for every offence he shall forfeit the value of the said Goods. *Vide Stat.* 15 *Car.* 2. 5.

All the Goods of an Alien Merchant or Factor in any of his Majesty's Plantations are forfeited. *Vide Stat.* 12 *Car.* 2. 18.

If any manner of Copper, Brass, Latten, Bell-metal, Pan-metal, Gun-metal, or Shroof-metal, shall be put on Board any Vessel to be transported, the offender shall forfeit double the value, to be divided betwixt the King and the Prosecutor. *Vide Stat.* 33 *Hen.* 8. 7.

And also ten pounds more for every thousand pound weight, *per Stat.* 2 & 3 *Edw.* 6. 37.

The Customer shall take Bond in double the value of the said Goods, when they shall be transported from Port to Port, and also 10 *l.* over and above for every thousand pounds weight and give Bond; which Bond if it want a Date, the Customer shall forfeit the value of the said Goods, and also his Place, *per id. Stat.*

If any Customer grant a false Certificate for the said Goods, he shall forfeit his Place, and the value of the Goods so concealed. 33 *Hen.* 8. 7.

If any Master of a Ship, Owner, Purser, or Boatswain, knowing such Metals to be Shipped, and do not disclose it within three days, he shall forfeit double the value of it. *Vide Stat.* 2 & 3 *Edw.* 6. 37.

If any Officer of the Custom-House, knowing such Metals to be Shipped to be transported, do not seize it, he shall lose his Office, and the value of the Goods so Shipped. *Vide Stat.* 2 & 3 *Edw.* 6. 37.

If any Person ship any of the said Metals at any place, except where there is a Customer, he shall forfeit the value of the Goods, and also ten pounds for every 1000 pound weight, *per id. Stat.*

If the Governor of any Plantation belonging to his Majesty, do not his Duty justly, according to the *Act for Encouragement of Trade*, he shall forfeit his Place and 1000 *l. per Stat.* 15 *Car.* 2. 15.

Every Person that shall be found guilty of transporting of Leather, shall for every Offence forfeit 500 *l. Vide Stat.* 14 *Car.* 2. 7.

Every Customer, or other Officer, that shall neglect his Duty, or connive at the Transportation of Leather, shall for every Offence forfeit 100 Pounds. *Vide Stat.* 1 *Jac.* 22.

Every Customer, or other Officer, that shall make a false Certificate of the Landing of Leather, shall forfeit 100 *l. per id. Stat.*

If any Goods or Merchandize shall be shipped or Landed at any unlawful time or place, for every Offence the Master, Owner, or Purser shall forfeit 100 *l.* 1 *Eliz.* 11. & 14 *Car* 2. 11.

Lawful

Lawful times are only from the first of March *until the first of* September, *betwixt Sun-rising and Sun-setting; and from the first of* September *until the first of* March *betwixt 7 a Clock in the Morning, and 4 a Clock in the Afternoon. The Port of* Hull *is here excepted.*

If the Captain, Master of a Ship, or Purser outward bound, shall take in any Goods before Entry, he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11.

If he go away before cleared on Oath in the Custom-house, giving a true Account of his Lading, *&c.* he shall foseit 100 *l. per id. Stat.*

If any Captain, Master of a Ship, or Purser, do not bring his Ship to the Port, and make Entry with as much speed as Wind and Water will permit, for every Offence he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2.

If he permit any Goods to be taken out of the Ship, to be Landed, before he hath made his general Entry upon Oath in the Custom-house, for every Offence he shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11.

If any Captain, Master of a Ship, Purser, or Boat-swain, or other Person taking Charge of the Ship, shall permit any sort of the Package therein to be opened, imbeazled, or altered, for every Offence he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11.

Men of War to be liable to the Rules that Merchants Ships are subject to Liberty to go on board and take out Prohibited and Uncustomed Goods. The Commissioners and their Deputies to enter on board, and bring on shore Goods outward and inward bound. The Officers may stay on board until the Goods be discharged. 14 *Car.* 2.

If any Goods be found concealed aboard the Ship, when the Officers of the Customs have cleared the Ship, the Master, or other Person, shall for every Offence forfeit 100 *l. per id. Stat.*

If any Wharfinger, Crane-keeper, Searcher, Lighter-man, or other Officer, knowing any Offence contrary to the Statute, do not disclose it to the Customer, he shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11.

If any Wharfinger or Crane-keeper shall take up or Land, or suffer to be Landed, or ship off, or suffer to be Water bound, any Wares or Merchandizes, at any unlawful time, or without the presence of, or notice given to an Officer at the Custom-house, he shall forfeit for every Offence 100 *l. per Stat.* 14 *Car.* 2. 11. The Port of *Hull* excepted.

If any Officers of the Customs shall directly or indirectly receive any Bribe, Recompence, or Reward, or shall connive at any false Entry of Goods, he shall forfeit 100 *l. per id. Stat.*

If any Merchant, or other person, shall give such Bribes, for every Offence he shall forfeit 50 *l. per id. Stat.*

If any Packet-Boat, or other Vessel appointed to carry Letters, shall Import or Export any Goods or Merchandize, for every Offence the Master shall forfeit 100 *l. per id. Stat.*

If any person offer to sale any Foreign Bone-Lace, Cut-work, Imbroidery, Fringe, or Needle-work made of Silk, or Thread, for every Offence he shall forfeit 50 *l. per id. Stat.*

If any of the said Goods be imported into *England* or *Wales*, the Offender shall forfeit 100 *l. per. id. Stat.*

If any Officer of any Port shall make a false Certificate, he shall forfeit 50 *l. per id. Stat.*

If any person shall falsify any Custom-house Warrant, he shall forfeit for every Offence 100 *l. per id. Stat.*

Every Officer appointed to perfect an Entry, shall make report thereof under his Hand, unto the Chief Officers of the Customs, the next day, upon the penalty of 100 *l.* unless there be cause of longer time to be allowed by the Chief Officers of the Customs, *per id. Stat.*

If any *French* Vessel put any Goods or Passengers on shore, or into any Boat, to be conveyed on shore, and not pay the five shillings *per* Tonnage due upon *French* Vessels, upon their return they shall forfeit ten pounds, and pay all the former Duty, *per id. Stat.*

If any Pilot or Waterman shall go out from any Port, to bring in any Goods or Passengers from aboard of any French Vessels, for every Offence he shall forfeit forty pounds *per id. Stat.*

If any Customer, Comptroller, or Searcher, or their Deputies, do not give their attendance at the Custom-House at such time and places as are appointed by Law, and also do not their utmost diligence in their respective places, for every Offence the Offender shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11.

If any Customer, Comptroller, or Searcher be not resident upon his Place and Office, for every Offence he shall forfeit 10 *l. Vide Stat.* 1 *Hen.* 4. 13. 4 *Hen.* 4. 20, 21. 13 *Hen.* 4. 5.

If any Custom-House Officers fraight any Ship, or use any Merchandize, or keep any Wharf, or hold any Hostery, or Tavern, or be Factor, or Attorney, or Host to any Merchant, for every Offence he shall forfeit 40 *l.* for every six Months, to be divided betwixt the King and the Prosecutor. *Vide Stat.* 20 *Hen.* 6. 5.

If any Customer, Comptroller, or Searcher, be a Common Officer, or Deputy to a Common Officer in a City, Borough or Town, upon the penalty of 40 *l.* for every six Months he shall Officiate both Offices together. *Vide Stat.* 3 *Hen.* 7. 1.

Quere, Whether this Statute be in Force or Repealed by the Stat. 1 Hen. 8. 5.

English Shipping is either *English* built, or bought *bona fide* with *English* Money, whereof every Owner, or part Owner, are *English*, *Irish*, *Welsh*, or of his Majesty's Plantations.

CANON

CANON TRIANGULORUM LOGARITHMICUS:

OR, A

TABLE

OF

ARTIFICIAL SINES

AND

TANGENTS

TO

Every DEGREE and MINUTE

OF THE

QUADRANT.

The Common Radius being 10, 000000.

By Capt. SAMUEL STURMY.

London, Printed for *Richard Mount*, 1700.

A Table of Artificial Sines and Tangents.

	Degree 0.				Degree 1.				
M	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang	
0	0.000000	10.000000	0.000000	*Infinita.*	8.241855	9.999934	8.241921	11.758079	60
1	6.463726	10.999999	6.463726	13.536274	8.249033	9.999932	8.249102	11.750898	59
2	6.764756	10.999999	6.764756	13.235244	8.256094	9.999929	8.256165	11.743835	58
3	6.940847	10.999999	6.940847	13.059153	8.263042	9.999927	8.263115	11.736885	57
4	7.065786	10.999999	7.065786	12.934214	8.269881	9.999925	8.269956	11.730044	56
5	7.162696	10.999999	7.162696	12.837304	8.276614	9.999922	8.276691	11.723309	55
6	7.241877	9.999999	7.241878	12.758122	8.283243	9.999920	8.283323	11.716677	54
7	7.308824	9.999999	7.308825	12.691175	8.289773	9.999918	8.289856	11.710144	53
8	7.366816	9.999999	7.366817	12.633183	8.296207	9.999915	8.296292	11.703708	52
9	7.417968	9.999999	7.417970	12.582030	8.302546	9.999913	8.302634	11.697366	51
10	7.463726	9.999998	7.463727	12.536273	8.308794	9.999910	8.308884	11.691116	50
11	7.505118	9.999998	7.505120	12.494880	8.314954	9.999907	8.315046	11.684954	49
12	7.542906	9.999997	7.542909	12.457091	8.321027	9.999905	8.321122	11.678878	48
13	7.577668	9.999997	7.577672	12.422328	8.327016	9.999902	8.327114	11.672886	47
14	7.609853	9.999996	7.609857	12.390143	8.332924	9.999819	8.333025	11.666975	46
15	7.639816	9.999996	7.639820	12.360180	8.338753	9.999817	8.338856	11.661144	45
16	7.667845	9.999995	7.667849	12.332151	8.344504	9.999894	8.344610	11.655390	44
17	7.694173	9.999995	7.694179	12.305821	8.350181	9.999891	8.350289	11.649711	43
18	7.718997	9.999994	7.719003	12.280997	8.355783	9.999888	8.355895	11.644105	42
19	7.742478	9.999993	7.742484	12.257516	8.361315	9.999885	8.361430	11.638570	41
20	7.764754	9.999993	7.764761	12.235239	8.366777	9.999882	8.366895	11.633105	40
21	7.785943	9.999992	7.785951	12.214049	8.372171	9.999879	8.372292	11,627708	39
22	7.806146	9.999991	7.806155	12.193845	8.377499	9.999876	8.377622	11.622378	38
23	7.825451	9.999990	7.825460	12.174540	8.382762	9.999873	8.382889	11.617111	37
24	7.843934	9.999989	7.843944	12.156056	8.387962	9.999870	8.388092	11.611908	36
25	7.861662	9.999989	7.861674	12.138326	8.393101	9.999867	8.393234	11.606766	35
26	7.878695	9.999988	7.878708	12.121292	8.398179	9.999864	8.398315	11.601685	34
27	7.895085	9.999987	7.895099	12.104901	8.403199	9.999861	8.403338	11.596662	33
28	7.910879	9.999986	7.910894	12.089106	8.408161	9.999858	8.408304	11.591696	32
29	7.926119	9.999985	7.926134	12.073866	8.413068	9.999854	8.413213	11.586787	31
30	7.940842	9.999983	7.940858	12.059142	8.417919	9.999851	8.418068	11.581932	30
31	7.955082	9.999982	7.955100	12.044900	8.422717	9.999848	8.422869	11.577131	29
32	7.968870	9.999981	7.968889	12.031111	8.427462	9.999844	8.427618	11.572382	28
33	7.982233	9.999980	7.982253	12.017747	8.432156	9.999841	8.432315	11.567685	27
34	7.995198	9.999979	7.995219	12.004781	8.436800	9.999838	8.436962	11.563038	26
35	8.007787	9.999977	7.007809	11.992191	8.441394	9.999834	8.441560	11.558440	25
36	8.020021	9.999976	8.020044	11.979956	8.445941	9.999831	8.446110	11.553990	24
37	8.031919	9.999975	8.031945	11.968055	8.450446	9.999827	8.450613	11.549387	23
38	8.043501	9.999973	8.043527	11.956473	8.454893	9.999824	8.455070	11.544930	22
39	8.054781	9.999972	8.054809	11.945191	8.459301	9.999820	8.459481	11.540519	21
40	8.065776	9.999971	8.065806	11.934194	8.463665	9.999816	8.463849	11.536151	20
41	8.076500	9.999969	8.076531	11.923469	8.467985	9.999813	8.468172	11.531828	19
42	8.086965	9.999968	8.086997	11.913003	8.472263	9.999809	8.472454	11.527546	18
43	8.097183	9.999966	8.097217	11.902783	8.476498	9.999805	8.476693	11.523307	17
44	8.107167	9.999964	8.107203	11.892797	8.480693	9.999801	8.480892	11.519108	16
45	8.116926	9.999963	8.116963	11.883037	8.484848	9.999797	8.485050	11.514950	15
46	8.126471	9.999961	8.126510	11.873490	8.488963	9.999794	8.489170	11.510830	14
47	8.135810	9.999959	8.135851	11.864149	8.493040	9.999790	8.493250	11.506750	13
48	8.144953	9.999958	8.144996	11.855004	8.497078	9.999786	8.497293	11.502707	12
49	8.153907	9.999956	8.153952	11.846048	8.501080	9.999782	8.501298	11.498702	11
50	8.162681	9.999954	8.162737	11.837273	8.505045	9.999778	8.505267	11.494733	10
51	8.171280	9.999952	8.171328	11.828672	8.508974	9.999774	8.509200	11.490800	9
52	8.179713	9.999950	8.179763	11.820237	8.512867	9.999769	8.513098	11.486902	8
53	8.187985	9.999948	8.188036	11.811964	8.516726	9.999765	8.516961	11.483039	7
54	8.196102	9.999946	8.196156	11.803844	8.520551	9.999761	8.520790	11.479210	6
55	8.204070	9.999944	8.204126	11.795874	8.524343	9.999757	8.524586	11.475414	5
56	8.211895	9.999942	8.211953	11.788047	8.528102	9.999753	8.528349	11.471651	4
57	8.219581	9.999940	8.219641	11.780359	8.531828	9.999748	8.532080	11.467920	3
58	8.227134	9.999938	8.227195	11.772805	8.535523	9.999744	8.535779	11.464221	2
59	8.234557	9.999936	8.234621	11.765379	8.539186	9.999740	8.539447	11.460552	1
60	8.241855	9.999934	8.241921	11.750879	8.542819	9.999735	8.543084	11.456916	0
	Co-sine	Sine	Co-tang	Tangent	Co-sine	Sine	Co-tang.	Tangent	M
	Degree 89.				Degree 88.				

	Degree 2.				Degree 3.				
M	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	8.542819	9.999735	8.543084	11.456916	8.718800	9.999404	8.719396	11.280604	60
1	8.546422	9.999731	8.546691	11.453309	8.721204	9.999398	8.721806	11.278194	59
2	8.549995	9.999726	8.550268	11.449732	8.723595	9.999391	8.724204	11.275796	58
3	8.553539	9.999722	8.553817	11.446183	8.725972	9.999384	8.726588	11.273412	57
4	8.557054	9.999717	8.557336	11.442664	8.728336	9.999378	8.728959	11.271041	56
5	8.560540	9.999713	8.560828	11.439172	8.730688	9.999371	8.731317	11.268683	55
6	8.563999	9.999708	8.564291	11.435709	8.733027	9.999364	8.733663	11.266337	54
7	8.567431	9.999704	8.567727	11.432273	8.735354	9.999357	8.735996	11.264004	53
8	8.570836	9.999699	8.571137	11.428863	8.737667	9.999350	8.738317	11.261683	52
9	8.574214	9.999694	8.574520	11.425480	8.739969	9.999343	8.740626	11.259374	51
10	8.577566	9.999689	8.577877	11.422123	8.742259	9.999336	8.742922	11.257078	50
11	8.580892	9.999685	8.581208	11.418792	8.744536	9.999329	8.745207	11.254793	49
12	8.584193	9.999680	8.584514	11.415486	8.746802	9.999322	8.747479	11.252521	48
13	8.587469	9.999675	8.587795	11.412205	8.749055	9.999315	8.749740	11.250260	47
14	8.590721	9.999670	8.591051	11.408949	8.751297	9.999308	8.751989	11.248011	46
15	8.593948	9.999665	8.594283	11.405717	8.753528	9.999301	8.754227	11.245773	45
16	8.597152	9.999660	8.597492	11.402508	8.755747	9.999294	8.756453	11.243547	44
17	8.600332	9.999655	8.600677	11.399323	8.757955	9.999287	8.758668	11.241332	43
18	8.603489	9.999650	8.603839	11.396161	8.760151	9.999279	8.760872	11.239128	42
19	8.606623	9.999645	8.606978	11.393022	8.762337	9.999272	8.763065	11.236935	41
20	8.609734	9.999640	8.610094	11.389906	8.764511	9.999265	8.765246	11.234754	40
21	8.612823	9.999635	8.613189	11.386811	8.766675	9.999257	8.767417	11.232583	39
22	8.615891	9.999629	8.616262	11.383738	8.768828	9.999250	8.769578	11.230422	38
23	8.618937	9.999624	8.619313	11.380687	8.770970	9.999242	8.771727	11.228273	37
24	8.621967	9.999619	8.622343	11.377657	8.773101	9.999235	8.773866	11.226134	36
25	8.624965	9.999614	8.625352	11.374648	8.775223	9.999227	8.775995	11.224005	35
26	8.627948	9.999608	8.628340	11.371660	8.777333	9.999220	8.778114	11.221886	34
27	8.630911	9.999603	8.631308	11.368692	8.779434	9.999212	8.780222	11.219778	33
28	8.633854	9.999597	8.634256	11.365744	8.781524	9.999205	8.782320	11.217680	32
29	8.636776	9.999592	8.637184	11.362816	8.783605	9.999197	8.784404	11.215592	31
30	8.639680	9.999586	8.640093	11.359907	8.785675	9.999189	8.786486	11.213514	30
31	8.642563	9.999581	8.642982	11.357017	8.787736	9.999181	8.788554	11.211446	29
32	8.645428	9.999575	8.645853	11.354147	8.789787	9.999174	8.790613	11.209387	28
33	8.648274	9.999570	8.648704	11.351296	8.791828	9.999166	8.792662	11.207338	27
34	8.651102	9.999564	8.651537	11.348463	8.793859	9.999158	8.794701	11.205299	26
35	8.653911	9.999558	8.654352	11.345648	8.795881	9.999150	8.796731	11.203269	25
36	8.656702	9.999553	8.657149	11.342851	8.797894	9.999142	8.798752	11.201248	24
37	8.659475	9.999547	8.659928	11.340072	8.799897	9.999134	8.800763	11.199237	23
38	8.662230	9.999541	8.662689	11.337311	8.801892	9.999126	8.802765	11.197235	22
39	8.664968	9.999535	8.665433	11.334567	8.803876	9.999118	8.804758	11.195242	21
40	8.667689	9.999529	8.668160	11.331840	8.805852	9.999110	8.806742	11.193258	20
41	8.670393	9.999524	8.670870	11.329130	8.807819	9.999102	8.808717	11.191283	19
42	8.673080	9.999518	8.673563	11.326437	8.809777	9.999094	8.810683	11.189317	18
43	8.675751	9.999512	8.676239	11.323761	8.811726	9.999086	8.812641	11.187359	17
44	8.678405	9.999506	8.678900	11.321100	8.813667	9.999077	8.814589	11.185411	16
45	8.681043	9.999500	8.681544	11.318456	8.815599	9.999069	8.816529	11.183471	15
46	8.683665	9.999493	8.684172	11.315828	8.817522	9.999061	8.818461	11.181539	14
47	8.686272	9.999487	8.686784	11.313216	8.819436	9.999053	8.820384	11.179616	13
48	8.688863	9.999481	8.689381	11.310619	8.821343	9.999044	8.822298	11.177702	12
49	8.691438	9.999475	8.691963	11.308037	8.823240	9.999036	8.824205	11.175795	11
50	8.693998	9.999469	8.694529	11.305471	8.825130	9.999027	8.826103	11.173897	10
51	8.696543	9.999463	8.697081	11.302919	8.827011	9.999019	8.827992	11.172008	9
52	8.699073	9.999456	8.699617	11.300383	8.828884	9.999010	8.829874	11.170126	8
53	8.701589	9.999450	8.702139	11.297861	8.830749	9.999002	8.831748	11.168252	7
54	8.704090	9.999443	8.704646	11.295354	8.832607	9.998993	8.833613	11.166387	6
55	8.706577	9.993437	8.707140	11.292860	8.834456	9.998984	8.835471	11.164529	5
56	8.709049	9.999431	8.709618	11.293082	8.836297	9.998976	8.837321	11.162679	4
57	8.711507	9.999424	8.712083	11.287917	8.838130	9.998967	8.839163	11.160837	3
58	8.713952	9.999418	8.714534	11.285466	8.839956	9.998958	8.840998	11.159002	2
59	8.716383	9.999411	8.716972	11.283028	8.841774	9.998950	8.842825	11.157175	1
60	8.718800	9.999404	8.719396	11.280604	8.843585	9.998941	8.844644	11.155356	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine.	Sine.	Co-tang.	Tangent	M.
	Degree 87.				Degree 86.				

Degree 4.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*
0	8.843584	9.998941	8.844644	11.155356
1	8.845387	9.998931	8.846455	11.153545
2	8.847183	9.998923	8.848260	11.151740
3	8.848971	9.998914	8.850057	11.149943
4	8.850751	9.998905	8.851846	11.148154
5	8.852525	9.998896	8.853628	11.146372
6	8.854291	9.998887	8.855403	11.144597
7	8.856049	9.998878	8.857171	11.142829
8	8.857801	9.998869	8.858932	11.141068
9	8.859546	9.998860	8.860686	11.139314
10	8.861283	9.998851	8.862423	11.137567
11	8.863014	9.998841	8.864173	11.135827
12	8.864738	9.998832	8.865906	11.134094
13	8.866455	9.998823	8.867632	11.132368
14	8.868165	9.998813	8.869351	11.130649
15	8.869868	9.998804	8.871064	11.128936
16	8.871565	9.998795	8.872750	11.127230
17	8.873255	9.998785	8.874469	11.125531
18	8.874938	9.998776	8.876162	11.123838
19	8.876615	9.998766	8.877849	11.122151
20	8.878285	9.998757	8.879529	11.120471
21	8.879949	9.998747	8.881202	11.118798
22	8.881607	9.998738	8.882869	11.117131
23	8.883258	9.998728	8.884530	11.115470
24	8.884903	9.998718	8.886185	11.113815
25	8.886542	9.998708	8.887833	11.112167
26	8.888174	9.998699	8.889476	11.110524
27	8.889801	9.998689	8.891112	11.108888
28	8.891421	9.998679	8.892742	11.107258
29	8.893035	9.998669	8.894366	11.105634
30	8.894643	9.998659	8.895984	11.104016
31	8.896246	9.998649	8.897596	11.192404
32	8.897842	9.998639	8.899203	11.190797
33	8.899432	9.998629	8.900803	11.099197
34	8.901017	9.998619	8.902398	11.097602
35	8.902596	9.998609	8.903987	11.096013
36	8.904169	9.998599	8.905570	11.094430
37	8.905736	9.998589	8.907147	11.092853
38	8.907297	9.998578	8.908719	11.091281
39	8.908853	9.998568	8.910285	11.089715
40	8.910404	9.998558	8.911846	11.088154
41	8.911949	9.998548	8.913401	11.086599
42	8.913488	9.998537	8.914951	11.085049
43	8.915022	9.998527	8.916495	11.083505
44	8.916550	9.998516	8.918034	11.081966
45	8.918073	9.998506	8.919568	11.080432
46	8.919591	9.998495	8.921096	11.078904
47	8.921103	9.998485	8.922619	11.077381
48	8.922610	9.998474	8.924136	11.075864
49	8.924112	9.998464	8.925649	11.074351
50	8.925609	9.998453	8.927156	11.072844
51	8.927100	9.998442	8.928658	11.071342
52	8.928587	9.998431	8.930155	11.069845
53	8.930068	9.998421	8.931647	11.068353
54	8.931544	9.998410	8.933134	11.066866
55	8.933015	9.998399	8.934616	11.065384
56	8.934481	9.998388	8.936093	11.063907
57	8.935942	9.998377	8.937565	11.062435
58	8.937398	9.998366	8.939032	11.060968
59	8.938850	9.998355	8.940494	11.059506
60	8.940296	9.998344	8.941952	11.058048
	Co-sine	Sine	*Co-tang.*	Tangent
Degree 85.				

Degree 5.				
Sine	*Co-sine*	Tangent	*Co-tang.*	
8.940296	9.998344	8.941952	11.058048	60
8.941738	9.998333	8.943404	11.056596	59
8.943174	9.998322	8.944852	11.055148	58
8.944606	9.998311	8.946295	11.053705	57
8.946034	9.998300	8.947734	11.052266	56
8.947456	9.998289	8.949168	11.050832	55
8.948874	9.998277	8.950597	11.049403	54
8.950287	9.998266	8.952021	11.047979	53
8.951696	9.998255	8.953441	11.046559	52
8.953100	9.998243	8.954856	11.045144	51
8.954499	9.998232	8.956267	11.043733	50
8.955894	9.998220	8.957674	11.042326	49
8.957284	9.998209	8.959075	11.040925	48
8.958670	9.998197	8.960473	11.039527	47
8.960052	9.998186	8.961866	11.038134	46
8.961429	9.998174	8.963255	11.036745	45
8.962801	9.998163	8.964639	11.035361	44
8.964170	9.998151	8.966019	11.033981	43
8.965534	9.998139	8.967394	11.032606	42
8.966893	9.998128	8.968766	11.031234	41
8.968249	9.998116	8.970133	11.029867	40
8.969600	9.998104	8.971496	11.028505	39
8.970947	9.998092	8.972855	11.027145	38
8.972289	9.998080	8.974209	11.025791	37
8.973628	9.998068	8.975560	11.024440	36
8.974962	9.998056	8.976906	11.023094	35
8.976293	9.998044	8.978248	11.021752	34
8.977619	9.998032	8.979586	11.020414	33
8.978941	9.998020	8.980921	11.019079	32
8.980259	9.998008	8.982251	11.017749	31
8.981573	9.997996	8.983577	11.016423	30
8.982883	9.997984	8.984899	11.015101	29
8.984189	9.997972	8.986217	11.013783	28
8.985491	9.997959	8.987532	11.012468	27
8.986789	9.997947	8.988842	11.011158	26
8.988083	9.997935	8.990149	11.009851	25
8.989374	9.997922	8.991451	11.008549	24
8.990660	9.997910	8.992750	11.007250	23
8.991943	9.997897	8.994045	11.005955	22
8.993228	9.997885	8.995337	11.004663	21
8.994497	9.997872	8.996624	11.003376	20
8.995768	9.997860	8.997908	11.002092	19
8.997036	9.997847	8.999188	11.000812	18
8.998299	9.997835	9.000465	11.999535	17
8.999560	9.997822	9.001738	11.998262	16
9.000816	9.997809	9.003007	11.996993	15
9.002069	9.997797	9.004272	11.995728	14
9.003318	9.997784	9.005534	11.994466	13
9.004563	9.997771	9.006792	11.993208	12
9.005805	9.997758	9.008047	11.991953	11
9.007044	9.997745	9.009298	11.990702	10
9.008278	9.997732	9.010546	11.989454	9
9.009510	9.997719	9.011790	11.988210	8
9.010737	9.997706	9.013031	11.986969	7
9.011962	9.997693	9.014268	11.985732	6
9.013182	9.997680	9.015502	11.984498	5
9.014400	9.997667	9.016732	11.983268	4
9.015613	9.997654	9.017959	11.982041	3
9.016824	9.997641	9.019183	11.980817	2
9.018031	9.997628	9.020403	11.979597	1
9.019235	9.997614	9.021620	11.978380	0
Co-sine,	Sine	*Co-tang.*	Tangent	M.
Degree 84.				

Degree 6.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.019235	9.997614	9.021620	10.978380
1	9.020435	9.997601	9.022834	10.977166
2	9.021632	9.997588	9.024044	10.975956
3	9.022825	9.997574	9.025251	10.974749
4	9.024016	9.997561	9.026455	10.973545
5	9.025203	9.997547	9.027655	10.972345
6	9.026386	9.997534	9.028852	10.971148
7	9.027567	9.997520	9.030046	10.969954
8	9.028744	9.997507	9.031237	10.968763
9	9.029918	9.997493	9.032425	10.967575
10	9.031089	9.997480	9.033609	10.966391
11	9.032257	9.997466	9.034791	10.965209
12	9.033421	9.997452	9.035969	10.964031
13	9.034582	9.997439	9.037144	10.962856
14	9.035741	9.997425	9.038316	10.961684
15	9.036896	9.997411	9.039485	10.960515
16	9.038048	9.997397	9.040651	10.959349
17	9.039197	9.997383	9.041813	10.958187
18	9.040342	9.997369	9.042973	10.957027
19	9.041485	9.997355	9.044130	10.955870
20	9.042625	9.997341	9.045284	10.954716
21	9.043762	9.997327	9.046434	10.953566
22	9.044895	9.997313	9.047582	10.952418
23	9.046026	9.997299	9.048727	10.951273
24	9.047154	9.997285	9.049869	10.950131
25	9.048279	9.997271	9.051008	10.948992
26	9.049400	9.997256	9.052144	10.947856
27	9.050519	9.997242	9.053277	10.946723
28	9.051635	9.997228	9.054407	10.945593
29	9.052749	9.997214	9.055535	10.944465
30	9.053859	9.997199	9.056650	10.943341
31	9.054966	9.997185	9.057781	10.942219
32	9.056071	9.997170	9.058900	10.941100
33	9.057172	9.997156	9.060016	10.939984
34	9.058271	9.997141	9.061130	10.938870
35	9.059367	9.997127	9.062240	10.937760
36	9.060460	9.997112	9.063348	10.936652
37	9.061551	9.997098	9.064453	10.935547
38	9.062639	9.997083	9.065556	10.934444
39	9.063724	9.997068	9.066655	10.933345
40	9.064806	9.997053	9.067752	10.932248
41	9.065885	9.997039	9.068846	10.931153
42	9.066962	9.997024	9.069938	10.930062
43	9.068036	9.997009	9.071027	10.928973
44	9.069107	9.996994	9.072113	10.927887
45	9.070176	9.996979	9.073197	10.926803
46	9.071242	9.996964	9.074278	10.925722
47	9.072306	9.996949	9.075356	10.924644
48	9.073366	9.996934	9.076432	10.923568
49	9.074424	9.996919	9.077505	10.922495
50	9.075480	9.996904	9.078576	10.921424
51	9.076533	9.996889	9.079644	10.920356
52	9.077583	9.996874	9.080710	10.919290
53	9.078631	9.996858	9.081773	10.918227
54	9.079676	9.996843	9.082833	10.917167
55	9.080719	9.996828	9.083891	10.916109
56	9.081759	9.996812	9.084947	10.915035
57	9.082797	9.996797	9.086000	10.914000
58	9.083832	9.996782	9.087050	10.912950
59	9.084864	9.996766	9.088098	10.911902
60	9.085894	9.996751	9.089144	10.910856
	Co-sine.	Sine	Co-tang.	Tangent

Degree 83.

Degree 7.

Sine	Co-sine	Tangent	Co-tang.	M
9.085894	9.996751	9.089144	10.910856	60
9.086922	9.996735	9.090187	10.909813	59
9.087947	9.996720	9.091228	10.908772	58
9.088970	9.996704	9.092266	10.907734	57
9.089990	9.996688	9.093302	10.906698	56
9.091008	9.996673	9.094336	10.905664	55
9.092024	9.996657	9.095367	10.904633	54
9.093037	9.996641	9.096395	10.903605	53
9.094047	9.996625	9.097422	10.902578	52
9.095056	9.996610	9.098446	10.901554	51
9.096062	9.996594	9.099468	10.900532	50
9.097065	9.996578	9.100487	10.899513	49
9.098066	9.996562	9.101504	10.898496	48
9.099065	9.996546	9.102519	10.897481	47
9.100062	9.996530	9.103532	10.896468	46
9.101056	9.996514	9.104542	10.895458	45
9.102048	9.996498	9.105550	10.894450	44
9.103037	9.996482	9.106556	10.893444	43
9.104025	9.996465	9.107559	10.892441	42
9.105010	9.996449	9.108560	10.891440	41
9.105992	9.996433	9.109559	10.890441	40
9.106973	9.996417	9.110556	10.889444	39
9.107951	9.996400	9.111551	10.888449	38
9.108927	9.996384	9.112543	10.887457	37
9.109901	9.996368	9.113533	10.886467	36
9.110873	9.996351	9.114521	10.885479	35
9.111842	9.996335	9.115507	10.884493	34
9.112809	9.996318	9.116491	10.883509	33
9.113774	9.996302	9.117472	10.882528	32
9.114737	9.996285	9.118452	10.881548	31
9.115698	9.996269	9.119429	10.880571	30
9.116656	9.996252	9.120404	10.879596	29
9.117613	9.996235	9.121377	10.878623	28
9.118567	9.996219	9.122348	10.877652	27
9.119519	9.996202	9.123317	10.876683	26
9.120469	9.996185	9.124284	10.875716	25
9.121417	9.996168	9.125249	10.874751	24
9.122362	9.996151	9.126211	10.873789	23
9.123306	9.996134	9.127172	10.872828	22
9.124248	9.996117	9.128130	10.871870	21
9.125187	9.996100	9.129087	10.870913	20
9.126125	9.996083	9.130041	10.869959	19
9.127060	9.996066	9.130994	10.869006	18
9.127993	9.996049	9.131944	10.868056	17
9.128925	9.996032	9.132893	10.867107	16
9.129854	9.996015	9.133839	10.866161	15
9.130781	9.995998	9.134784	10.865216	14
9.131706	9.995980	9.135726	10.864274	13
9.132630	9.995963	9.136667	10.863333	12
9.133551	9.995946	9.137605	10.862395	11
9.134470	9.995928	9.138542	10.861458	10
9.135387	9.995911	9.139476	10.860524	9
9.136303	9.995894	9.140409	10.859591	8
9.137216	9.995876	9.141340	10.858660	7
9.138128	9.995859	9.142269	10.857731	6
9.139037	9.995841	9.143196	10.856804	5
9.139944	9.995823	9.144121	10.855879	4
9.140850	9.995806	9.145044	10.854956	3
9.141754	9.995788	9.145966	10.854034	2
9.142655	9.995771	9.146885	10.853115	1
9.143555	9.995753	9.147803	10.852197	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 82.

M	Degree 8.				Degree 9.				
M	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.143555	9.995753	9.147803	10.852197	9.194332	9.994620	9.199713	10.800287	60
1	9.144453	9.995735	9.148718	10.851282	9.195129	9.994600	9.200529	10.799471	59
2	9.145349	9.995717	9.149632	10.850368	9.195925	9.994580	9.201345	10.798655	58
3	9.146243	9.995699	9.150544	10.849456	9.196719	9.994560	9.202159	10.797841	57
4	9.147136	9.995681	9.151454	10.848546	9.197511	9.994540	9.202971	10.797029	56
5	9.148026	9.995664	9.152363	10.847637	9.198302	9.994519	9.203782	10.796218	55
6	9.148915	9.995646	9.153269	10.846731	9.199091	9.994499	9.204592	10.795408	54
7	9.149802	9.995628	9.154174	10.845826	9.199879	9.994479	9.205400	10.794600	53
8	9.150686	9.995610	9.155077	10.844923	9.200666	9.994459	9.206207	10.793793	52
9	9.151569	9.995591	9.155978	10.844022	9.201451	9.994438	9.207013	10.792987	51
10	9.152451	9.995573	9.156877	10.843123	9.202234	9.994418	9.207817	10.792183	50
11	9.153330	9.995555	9.157775	10.842225	9.203017	9.994398	9.208619	10.791381	49
12	9.154208	9.995537	9.158671	10.841329	9.203797	9.994377	9.209420	10.790580	48
13	9.155083	9.995519	9.159565	10.840435	9.204577	9.994357	9.210220	10.789780	47
14	9.155957	9.995501	9.160457	10.839543	9.205354	9.994336	9.211018	10.788982	46
15	9.156830	9.995482	9.161347	10.838653	9.206131	9.994316	9.211815	10.788185	45
16	9.157700	9.995464	9.162236	10.837764	9.206906	9.994295	9.212611	10.787389	44
17	9.158569	9.995446	9.163123	10.836877	9.207679	9.994274	9.213405	10.786595	43
18	9.159435	9.995427	9.164008	10.835992	9.208452	9.994254	9.214198	10.785802	42
19	9.160301	9.995409	9.164892	10.835108	9.209222	9.994233	9.214989	10.785011	41
20	9.161164	9.995390	9.165774	10.834226	9.209992	9.994212	9.215780	10.784220	40
21	9.162025	9.995372	9.166654	10.833346	9.210760	9.994191	9.216568	10.783432	39
22	9.162885	9.995353	9.167532	10.832468	9.211526	9.994171	9.217356	10.782644	38
23	9.163743	9.995334	9.168409	10.831591	9.212291	9.994150	9.218142	10.781858	37
24	9.164600	9.995316	9.169284	10.830716	9.213055	9.994129	9.218926	10.781074	36
25	9.165454	9.995297	9.170157	10.829843	9.213818	9.994108	9.219710	10.780290	35
26	9.166307	9.995278	9.171029	10.828971	9.214579	9.994087	9.220492	10.779508	34
27	9.167159	9.995260	9.171899	10.828101	9,215338	9.994066	9.221272	10.778728	33
28	9.168008	9.995241	9.172767	10.827233	9.216097	9.994044	9.222052	10.777948	32
29	9.168856	9.995222	9.173634	10.826366	9.216854	9.994024	9.222830	10.777170	31
30	9.169702	9.995203	9.174499	10.825501	9.217609	9.994003	9.223607	10.776393	30
31	9.170547	9.995184	9.175362	10.824638	9.218363	9.993982	9.224382	10.775681	29
32	9.171389	9.995165	9.176224	10.823776	9.219116	9.993960	9.225156	10.774844	28
33	9.172230	9.995146	9.177084	10.822916	9.219868	9.993939	9.225929	10.774071	27
34	9.173070	9.995127	9.177942	10.822058	9.220618	9.993918	9.226704	10.773300	26
35	9.173908	9.995108	9.178799	10.821201	9.221367	9.993897	9.227471	10.772529	25
36	9.174744	9.995089	9.179655	10.820345	9.222115	9.993875	9.228239	10.771760	24
37	9.175578	9.995070	9.180508	10.819492	9.222861	9.993854	9.229007	10.770993	23
38	9.176411	9.995051	9.181360	10.818640	9.223606	9.993832	9.229773	10.770227	22
39	9.177242	9.995032	9.182211	10.817789	9.224349	9.993811	9.230539	10.769461	21
40	9.178072	9.995013	9.183059	10.816940	9.225092	9.993789	9.231302	10.768698	20
41	9.178900	9.994993	9.183907	10.816093	9.225833	9.993768	9.232065	10.767935	19
42	9.179726	9.994974	9.184752	10.815248	9.226573	9.993746	9,232826	10.767174	18
43	9.180551	9.994955	9.185597	10.814403	9.227311	9.993725	9.233586	10.766414	17
44	9.181374	9.994935	9.186439	10.813561	9.228048	9.993703	9.234345	10.765655	16
45	9.182196	9.994916	9.187280	10.812720	9.228784	9.993681	9.235103	10.764897	15
46	9.183016	9.994896	9.188120	10.811880	9.229518	9.993660	9.235859	10.764141	14
47	9.183834	9.994877	9.188958	10.811042	9.230252	9.993638	9.236614	10.763386	13
48	9.184651	9.994857	9.189794	10.810206	9.230984	9.993616	9.237368	10.762632	12
49	9.185466	9.994838	9.190629	10.809371	9.231715	9.993594	9.238120	10.761880	11
50	9.186280	9.994818	9.191462	10.808538	9.232444	9.993572	9.238872	10.761128	10
51	9.187092	9,994798	9.192294	10.807706	9.233172	9.993550	9.239622	10.760378	9
52	9.187903	9.994779	9.193124	10.806876	9.233899	9.993528	9.240371	10.759629	8
53	9.188712	9.994759	9.193953	10.806047	9.234625	9.993506	9.241118	10.758882	7
54	9.189519	9.994739	9.194780	10.805220	9.235349	9.993484	9.241865	10.758135	6
55	9.190325	9.994720	9.195606	10.804394	9.236073	3.993462	9.242610	10.757390	5
56	9.191130	9.994700	9.196430	10.803570	9.236795	9.993440	9.243354	10.756646	4
57	9.191933	9.994680	9.197253	10.802747	9.237515	9.993418	9.244097	10.755903	3
58	9.192734	9.994660	9.198074	10.801926	9.238235	9.993396	9.244839	10.755161	2
59	9.193534	9.994640	9.198894	10.801106	9.238953	9.993374	9.245579	10.754421	1
60	9.194332	9.994620	9.199713	10.800287	9.239670	9.993351	9.246319	10.753681	0
	Co-sine.	Sine	Co-tang.	Tangent	Co-sine.	Sine	Co-tang.	Tangent	M
	Degree 81.				Degree 80.				

	Degree 10.				Degree 11.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tagn.*	
0	9.239670	9.993351	9.246319	10.753681	9.280599	9.991974	9.288652	10.711348	60
1	9.240386	9.993329	9.247057	10.752943	9.281248	9.991922	9.289326	10.710674	59
2	9.241101	9.993307	9.247794	10.752206	9.281897	9.991897	9.289999	10.710001	58
3	9.241814	9.993284	9.248530	10.751470	9.282544	9.991873	9.290671	10.709329	57
4	9.242526	9.993262	9.249264	10.750736	9.283190	9.991848	9.291342	10.708658	56
5	9.243237	9.993240	9.249998	10.750002	9.283836	9.991823	9.292013	10.707987	55
6	9.243947	9.993217	9.250730	10.749270	9.284480	9.991799	9.292682	10.707318	54
7	9.244656	9.993195	9.251461	10.748539	9.285124	9.991774	9.293350	10.706650	53
8	9.245363	9.993172	9.252191	10.747809	9.285766	9.991749	9.294017	10.705983	52
9	9.246069	9.993149	9.252920	10.747080	9.286408	9.991724	9.294684	10.705316	51
10	9.246775	9.993127	9.253648	10.746352	9.287048	9.991699	9.295349	10.704651	50
11	9.247478	9.993104	9.254374	10.745626	9.287688	9.991674	9.296013	10.703987	49
12	9.248181	9.993081	9.255100	10.744900	9.288326	9.991649	9.296677	10.703323	48
13	9.248883	9.993059	9.255824	10.744176	9.288964	9.991624	9.297339	10.702661	47
14	9.249583	9.993036	9.256547	10.743453	9.289600	9.991599	9.298001	10.701999	46
15	9.250282	9.993013	9.257269	10.742731	9.290236	9.991574	9.298662	10.701338	45
16	9.250980	9.992990	9.257990	10.742010	9.290870	9.991549	9.299322	10.700678	44
17	9.251677	9.992967	9.258710	10.741290	9.291504	9.991524	9.299980	10.700020	43
18	9.252373	9.992944	9.259429	10.740571	9.292137	9.991498	9.300638	10.699362	42
19	9.253067	9.992921	9.260146	10.739854	9.292768	9.991473	9.301295	10.698705	41
20	9.253761	9.992898	9.260863	10.739137	9.293399	9.991448	9.301951	10.698049	40
21	9.254453	9.992875	9.261578	10.738422	9.294029	9.991422	9.302607	10.697393	39
22	9.255144	9.992852	9.262292	10.737708	9.294658	9.991397	9.303261	10.696739	38
23	9.255834	9.992829	9.263005	10.736995	9.295286	9.991372	9.303914	10.696086	37
24	9.256523	9.992806	9.263717	10.736283	9.295913	9.991346	9.304567	10.695433	36
25	9.257211	9.992783	9.264428	10.735572	9.296539	9.991321	9.305218	10.694782	35
26	9.257898	9.992759	9.265138	10.734862	9.297164	9.991295	9.305869	10.694131	34
27	9.258583	9.992736	9.265847	10.734153	9.297788	9.991270	9.306519	10.693481	33
28	9.259268	9.992713	9.266555	10.733445	9.298412	9.991244	9.307168	10.692832	32
29	9.259951	9.992690	9.267261	10.732739	9.299034	9.991218	9.307816	10.692184	31
30	9.260633	9.992666	9.267967	10.732033	9.299655	9.991193	9.308463	10.691537	30
31	9.261314	9.992643	9.268671	10.731329	9.300276	9.991167	9.309109	10.690891	29
32	9.261994	9.992619	9.269375	10.730625	9.300895	9.991141	9.309754	10.690246	28
33	9.262673	9.992596	9.270077	10.729923	9.301514	9.991115	9.310399	10.689601	27
34	9.263351	9.992527	9.270779	10.729221	9.302132	9.991090	9.311042	10.688958	26
35	9.264027	9.992549	9.271479	10.728521	9.302748	9.991064	9.311685	10.688315	25
36	9.264703	9.992525	9.272178	10.727822	9.303364	9.991038	9.312327	10.687673	24
37	9.265377	9.992501	9.272876	10.727124	9.303979	9.991012	9.312968	10.687032	23
38	9.266051	9.992478	9.273573	10.726427	9.304593	9.990986	9.313608	10.686392	22
39	9.266723	9.992454	9.274269	10.725731	9.305207	9.990960	9.314247	10.685753	21
40	9.267395	9.992430	9.274964	10.725036	9.305819	9.990934	9.314885	10.685115	20
41	9.268065	9.992406	9.275658	10.724342	9.306430	9.990908	9.315523	10.684477	19
42	9.268734	9.992382	9.276351	10.723649	9.307041	9.990882	9.316159	10.683841	18
43	9.269402	9.992359	9.277043	10.722957	9.307650	9.990855	9.316795	10.683205	17
44	9.270069	9.992335	9.277734	10.722266	9.308259	9.990829	9.317430	10.682570	16
45	9.270735	9.992311	9.278424	10.721576	9.308867	9.990803	9.318064	10.681936	15
46	9.271400	9.992287	9.279113	10.720887	9.309474	9.990777	9.318697	10.681303	14
47	9.272064	9.992263	9.279801	10.720199	9.310080	9.990750	9.319330	10.680670	13
48	9.272726	9.992239	9.280488	10.719512	9.310685	9.990724	9.319961	10.680039	12
49	9.273388	9.992214	9.281174	10.718826	9.311289	9.990697	9.320592	10.679408	11
50	9.274049	9.992190	9.281858	10.718142	9.311893	9.990671	9.321222	10.678778	10
51	9.274708	9.992166	9.282542	10.717458	9.312495	9.990645	9.321851	10.678149	9
52	9.275367	9.992142	9.283225	10.716775	9.313097	9.990618	9.322479	10.677521	8
53	9.276025	9.992118	9.283907	10.716093	9.313698	9.990591	9.323106	10.676894	7
54	9.276681	9.992093	9.284588	10.715412	9.314297	9.990565	9.323733	10.676267	6
55	9.277337	9.992069	9.285268	10.714732	9.314897	9.990538	9.324358	10.675642	5
56	9.277991	9.992044	9.285947	10.714053	9.315495	9.990511	9.324983	10.675017	4
57	9.278645	9.992020	9.286624	10.713376	9.316092	9.990485	9.325607	10.674393	3
58	9.279297	9.991996	9.287301	10.712699	9.316689	9.990458	9.326231	10.673769	2
59	9.279948	9.991971	9.287977	10.712023	9.317284	9.990431	9.326853	10.673147	1
60	9.280599	9.991947	9.288652	10.711348	9.317879	9.990404	9.327475	10.672525	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine*	Sine	*Co-tang.*	Tangent	M
	Degree 79.				Degree 78.				

	Degree 12.				Degree 13.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.317879	9.990404	9.327475	10.672525	9.352088	9.988724	9.363364	10.636636	60
1	9.318473	9.990378	9.328095	10.671905	9.352635	9.988695	9.363940	10.636060	59
2	9.319066	9.990351	9.328715	10.671285	9.353181	9.988666	9.364515	10.635485	58
3	9.319658	9.990324	9.329334	10.670666	9.353726	9.988636	9.365090	10.634910	57
4	9.320250	9.990297	9.329953	10.670047	9.354271	9.988607	9.365664	10.634336	56
5	9.320840	9.990270	9.330570	10.669430	9.354815	9.988578	9.366237	10.633763	55
6	9.321430	9.990243	9.331187	10.668813	9.355358	9.988548	9.366810	10.633190	54
7	9.322019	9.990215	9.331803	10.668197	9.355901	9.988519	9.367382	10.632618	53
8	9.322607	9.990188	9.332418	10.667582	9.356443	9.988489	9.367953	10.632047	52
9	9.323194	9.990161	9.333033	10.666967	9.356984	9.988460	9.368524	10.631476	51
10	9.323780	9.990134	9.333646	10.666354	9.357524	9.988430	9.369094	10.630906	50
11	9.324366	9.990107	9.334259	10.665741	9.358064	9.988401	9.369663	10.630337	49
12	9.324950	9.990079	9.334871	10.665129	9.358603	9.988371	9.370232	10.629768	48
13	9.325534	9.990052	9.335482	10.664518	9.359141	9.988342	9.370799	10.629201	47
14	9.326117	9.990025	9.336093	10.663907	9.359678	9.988312	9.371367	10.628633	46
15	9.326700	9.989997	9.336702	10.663298	9.360215	9.988282	9.371933	10.628067	45
16	9.327281	9.989970	9.337311	10.662689	9.360752	9.988252	9.372499	10.627501	44
17	9.327862	9.989942	9.337919	10.662081	9.361287	9.988223	9.373064	10.626936	43
18	9.328442	9.989915	9.338527	10.661473	9.361822	9.988193	9.373629	10.626371	42
19	9.329020	9.989887	9.339133	10.660867	9.362356	9.988163	9.374193	10.625807	41
20	9.329599	9.989860	9.339739	10.660261	9.362889	9.988133	9.374756	10.625244	40
21	9.330176	9.989832	9.340344	10.659656	9.363422	9.988103	9.375319	10.624681	39
22	9.330753	9.989804	9.340948	10.659052	9.363954	9.988073	9.375881	10.624119	38
23	9.331329	9.989777	9.341552	10.658448	9.364485	9.988043	9.376442	10.623558	37
24	9.331903	9.989749	9.342155	10.657845	9.365016	9.988013	9.377003	10.622997	36
25	9.332478	9.989721	9.342757	10.657243	9.365546	9.987983	9.377563	10.622437	35
26	9.333051	9.989693	9.343358	10.656642	9.366075	9.987953	9.378122	10.621878	34
27	9.333624	9.989665	9.343958	10.656042	9.366604	9.987922	9.378681	10.621319	33
28	9.334195	9.989637	9.344558	10.655442	9.367132	9.987892	9.379239	10.620761	32
29	9.334767	9.989610	9.345157	10.654843	9.367659	9.987862	9.379797	10.620203	31
30	9.335337	9.989582	9.345755	10.654245	9.368185	9.987832	9.380354	10.619646	30
31	9.335906	9.989553	9.346353	10.653647	9.368711	9.987801	9.380910	10.619090	29
32	9.336475	9.989525	9.346949	10.653051	9.369236	9.987771	9.381466	10.618534	28
33	9.337043	9.989497	9.347545	10.652455	9.369761	9.987740	9.382020	10.617980	27
34	9.337610	9.989469	9.348141	10.651859	9.370285	9.987710	9.382575	10.617425	26
35	9.338176	9.989441	9.348735	10.651265	9.370808	9.987679	9.383129	10.616871	25
36	9.338742	9.989413	9.349329	10.650671	9.371330	9.987649	9.383682	10.616318	24
37	9.339307	9.989385	9.349922	10.650078	9.371852	9.987618	9.384234	10.615766	23
38	9.339871	9.989356	9.350514	10.649486	9.372373	9.987588	9.384786	10.615214	22
39	9.340434	9.989328	9.351106	10.648894	9.372894	9.987557	9.385337	10.614663	21
40	9.340996	9.989300	9.351697	10.648303	9.373414	9.987526	9.385888	10.614112	20
41	9.341558	9.989271	9.352287	10.647713	9.373933	9.987496	9.386438	10.613562	19
42	9.342119	9.989243	9.352876	10.647124	9.374452	9.987465	9.386987	10.613013	18
43	9.342679	9.989214	9.353465	10.646535	9.374970	9.987434	9.387536	10.612464	17
44	9.343239	9.989186	9.354053	10.645947	9.375487	9.987403	9.388084	10.611916	16
45	9.343797	9.989157	9.354640	10.645360	9.376003	9.987372	9.388631	10.611369	15
46	9.344355	9.989128	9.355227	10.644773	9.376519	9.987341	9.389178	10.610822	14
47	9.344912	9.989100	9.355813	10.644187	9.377035	9.987310	9.389724	10.610276	13
48	9.345469	9.989071	9.356398	10.643602	9.377549	9.987279	9.390270	10.609730	12
49	9.346024	9.989042	9.356982	10.643018	9.378063	9.987248	9.390815	10.609185	11
50	9.346579	9.989014	9.357566	10.642434	9.378577	9.987217	9.391360	10.608640	10
51	9.347134	9.988985	9.358149	10.641851	9.379089	9.987186	9.391903	10.608097	9
52	9.347687	9.988956	9.358731	10.641269	9.379601	9.987155	9.392447	10.607553	8
53	9.348240	9.988927	9.359313	10.640687	9.380113	9.987124	9.392989	10.607011	7
54	9.348792	9.988898	9.359893	10.640107	9.380624	9.987092	9.393531	10.606469	6
55	9.349343	9.988869	9.360474	10.639526	9.381134	9.987061	9.394073	10.605927	5
56	9.349893	9.988840	9.361053	10.638947	9.381643	9.987030	9.394614	10.605386	4
57	9.350443	9.988811	9.361632	10.638368	9.382152	9.986998	9.395154	10.604846	3
58	9.350992	9.988782	9.362210	10.637790	9.382661	9.986967	9.395694	10.604306	2
59	9.351540	9.988753	9.362787	10.637213	9.383168	9.986936	9.396233	10.603767	1
60	9.352088	9.988724	9.363364	10.636636	9.383675	9.986904	9.396771	10.603229	0
	Co-sine.	Sine	*Co-tang.*	Tangent	*Co-sine.*	Sine	*Co-tang.*	Tangent	M
	Degree 77.				Degree 76.				

	Degree 14.				Degree 15.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.383675	9.986904	9.396771	10.603229	9.412996	9.984944	9.428052	10.571948	60
1	9.384182	9.986873	9.397309	10.602691	9.413467	9.984910	9.428558	10.571442	59
2	9.384687	9.986841	9.397846	10.602154	9.413938	9.984876	9.429062	10.570938	58
3	9.385192	9.986809	9.398383	10.601617	9.414408	9.984842	9.429566	10.570434	57
4	9.385697	9.986778	9.398919	10.601081	9.414878	9.984808	9.430070	10.569930	56
5	9.386201	9.986746	9.399455	10.600545	9.415347	9.984774	9.430573	10.569427	55
6	9.386704	9.986714	9.399990	10.600010	9.415815	9.984740	9.431075	10.568925	54
7	9.387207	9.986683	9.400524	10.599476	9.416283	9.984706	9.431577	10.568423	53
8	9.387709	9.986651	9.401058	10.598942	9.416851	9.984672	9.432079	10.567921	52
9	9.388210	9.986619	9.401591	10.598409	9.417217	9.984638	9.432580	10.567420	51
10	9.388711	9.986587	9.402124	10.597876	9.417684	9.984603	9.433080	10.566920	50
11	9.389211	9.986555	9.402656	10.597344	9.418150	9.984569	9.433580	10.566420	49
12	9.389711	9.986523	9.403187	10.596813	9.418615	9.984535	9.434080	10.565920	48
13	9.390210	9.986491	9.403718	10.596282	9.419079	9.984500	9.434579	10.565421	47
14	9.390708	9.986459	9.404249	10.595751	9.419544	9.984466	9.435078	10.564922	46
15	9.391206	9.986427	9.404778	10.595222	9.420007	9.984432	9.435576	10.564424	45
16	9.391703	9.986395	9.405308	10.594692	9.420470	9.984397	9.436073	10.563927	44
17	9.392199	9.986363	9.405836	10.594164	9.420933	9.984363	9.436570	10.563430	43
18	9.392695	9.986331	9.406364	10.593636	9.421395	9.984328	9.437067	10.562933	42
19	9.393191	9.986299	9.406892	10.593108	9.421857	9.984294	9.437563	10.562437	41
20	9.393685	9.986266	9.407419	10.592581	9.422318	9.984259	9.438059	10.561941	40
21	9.394179	9.986234	9.407945	10.592055	9.422778	9.984224	9.438554	10.561446	39
22	9.394673	9.986202	9.408471	10.591529	9.423238	9.984190	9.439048	10.560952	38
23	9.395166	9.986169	9.408996	10.591004	9.423697	9.984155	9.439543	10.560457	37
24	9.395658	9.986137	9.409521	10.590479	9.424156	9.984120	9.440036	10.559964	36
25	9.396150	9.986104	9.410045	10.589955	9.424615	9.984085	9.440529	10.559471	35
26	9.396641	9.986072	9.410569	10.589431	9.425073	9.984050	9.441022	10.558978	34
27	9.397132	9.986039	9.411092	10.588908	9.425530	9.9840[illegible]5	9.441514	10.558486	33
28	9.397621	9.986007	9.411615	10.588385	9.425987	9.983981	9.442006	10.557994	32
29	9.398111	9.985974	9.412137	10.587863	9.426443	9.983946	9.442497	10.557503	31
30	9.398600	9.985942	9.412658	10.587342	9.426899	9.983911	9.442988	10.557012	30
31	9.399088	9.985909	9.413179	10.586821	9.427354	9.983875	9.443479	10.556521	29
32	9.399575	9.985876	9.413699	10.586301	9.427809	9.983840	9.443968	10.556032	28
33	9.400062	9.985843	9.414219	10.585781	9.428263	9.983805	9.444458	10.555542	27
34	9.400549	9.985811	9.414738	10.585262	9.428717	9.983770	9.444947	10.555053	26
35	9.401035	9.985778	9.415257	10.584743	9.429170	9.983735	9.445435	10.554565	25
36	9.401520	9.985745	9.415775	10.584225	9.429623	9.983700	9.445923	10.554077	24
37	9.402005	9.985712	9.416293	10.583707	9.430075	9.983664	9.446411	10.553589	23
38	9.402489	9.985679	9.416810	10.583190	9.430527	9.983626	9.446898	10.553102	22
39	9.402972	9.985646	9.417326	10.582674	9.430978	9.983594	9.447384	10.552616	21
40	9.403455	9.985613	9.417842	10.582158	9.431429	9.983558	9.447870	10.552130	20
41	9.403938	9.985580	9.418358	10.581642	9.431879	9.983523	9.448356	10.551644	19
42	9.404420	9.985547	9.418873	19.581127	9.432329	9.983487	9.448841	10.551159	18
43	9.404901	9.985514	9.419387	10.580613	9.432778	9.983452	9.449326	10.550674	17
44	9.405382	9.985480	9.419901	10.580099	9.433206	9.983416	9.449810	10.550190	16
45	9.405862	9.985447	9.420415	10.579585	9.433675	9.983381	9.440294	10.549706	15
46	9.406341	9.985414	9.420927	10.579073	9.434122	9.983345	9.450777	10.549223	14
47	9.406820	9.985381	9.421440	10.578560	9.434569	9.983309	9.451260	10.548740	13
48	9.407299	9.985347	9.421952	10.578048	9.435016	9.983273	9.451743	10.548257	12
49	9.407777	9.985314	9.422463	10.577537	9.435462	9.983238	9.452225	10.547775	11
50	9.408254	9.985280	9.422974	10.577026	9.435908	9.983202	9.452706	10.547294	10
51	9.408731	9.985247	9.423484	10.576516	9.436353	9.983166	9.453187	10.546813	9
52	9.409207	9.985213	9.423993	10.576007	9.436798	9.983130	9.453668	10.546332	8
53	9.409682	9.985180	9.424503	10.575497	9.437242	9.983094	9.454148	10.545852	7
54	9.410157	9.985146	9.425011	10.574989	9.437686	9.983058	6.454628	10.545372	6
55	9.410632	9.985113	9.425519	10.574481	9.438129	9.983022	9.455107	10.544893	5
56	9.411106	9.985079	9.426027	10.573973	9.438572	9.982986	9.455586	10.544414	4
57	9.411579	9.985045	9.426534	10.573466	9.439014	9.982950	9.456064	10.543936	3
58	9.412052	9.985011	9.427041	10.572959	9.439456	9.982914	9.456542	10.543458	2
59	9.412524	9.984978	9.427547	10.572453	9.439897	9.982878	9.457019	10.542981	1
60	9.412996	9.984944	9.428052	10.571948	9.440338	9.982842	9.457496	10.542504	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine*	Sine	*Co-tang.*	Tangent	M
	Degree 75.				Degree 74.				

M	Degree 16.				Degree 17.				
M	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.440338	9.982842	9.457496	10.542504	9.465935	9.980596	9.485339	10.514661	60
1	9.440778	9.982805	9.457973	10.542027	9.466348	9.980558	9.485791	10.514209	59
2	9.441218	9.982769	9.458449	10.541551	9.466761	9.980519	9.486242	10.513758	58
3	9.441658	9.982733	9.458925	10.541075	9.467173	9.980482	9.486693	10.513307	57
4	9.442096	9.982696	9.459400	10.540600	9.467585	9.980442	9.487143	10.512857	56
5	9.442535	9.982660	9.459875	10.540125	9.467996	9.980403	9.487593	10.512407	55
6	9.442973	9.982624	9.460349	10.539651	9.468407	9.980364	9.488043	10.511957	54
7	9.443410	9.982587	9.460829	10.539177	9.468817	9.980325	9.488492	10.511508	53
8	9.443847	9.982550	9.461297	10.538703	9.469227	9.980286	9.488941	10.511059	52
9	9.444284	9.982514	9.461770	10.538230	9.469637	9.980247	9.489390	10.510610	51
10	9.444720	9.982477	9.462242	10.537758	9.460446	9.980208	9.489838	10.510162	50
11	9.445155	9.982441	9.462715	10.537285	9.470455	9.980169	9.490286	10.509714	49
12	9.445590	9.982404	9.463186	10.536814	9.470863	9.980130	9.490733	10.509267	48
13	9.446025	9.982367	9.463658	10.536342	9.471071	9.980091	9.491180	10.508820	47
14	9.446459	9.982330	9.464128	10.535872	9.471679	9.980052	9.491627	10.508373	46
15	9.446893	9.982294	9.464599	10.535401	9.472086	9.980012	9.492073	10.507927	45
16	9.447326	9.982257	9.465069	10.534931	9.472492	9.979973	9.492519	10.507481	44
17	9.447759	9.982220	9.465539	10.534461	9.472898	9.979934	9.492965	10.507035	43
18	9.448191	9.982183	9.466008	10.533992	9.473304	9.979894	9.493410	10.506590	42
19	9.448623	9.982146	9.466477	10.533523	9.473710	9.979855	9.493854	10.506146	41
20	9.449054	9.982109	9.466945	10.533055	9.474115	9.979816	9.494299	10.505701	40
21	9.449485	9.982072	9.467413	10.532587	9.474519	9.979776	9.494743	10.505257	39
22	9.449915	9.982035	9.467880	10.532120	9.474923	9.979737	9.495186	10.504814	38
23	9.450345	9.981998	9.468347	10.531653	9.475327	9.979697	9.495630	10.504370	37
24	9.450775	9.981961	9.468814	10.531186	9.475730	9.979658	9.496073	10.503927	36
25	9.451204	9.981924	9.469280	10.530720	9.476133	9.979618	9.496515	10.503485	35
26	9.451632	9.981886	9.469746	10.530253	9.476536	9.979579	9.496957	10.503043	34
27	9.452060	9.981849	9.470211	10.529789	9.476938	9.979539	9.497399	10.502601	33
28	9.452488	9.981812	9.470676	10.529324	9.477340	9.979499	9.497841	10.502159	32
29	9.452915	9.981774	9.471141	10.528859	9.477741	9.979459	9.498282	10.501718	31
30	9.453342	9.981737	9.471605	10.528395	9.478142	9.979420	9.498722	10.501278	30
31	9.453768	9.981700	9.472068	10.527931	9.478542	9.979380	9.499163	10.500837	29
32	9.454194	9.981662	9.472532	10.527468	9.478942	9.979340	9.499603	10.500397	28
33	9.454619	9.981625	9.472995	10.527005	9.479342	9.979300	9.500042	10.499958	27
34	9.455044	9.981587	9.473457	10.526543	9.479741	9.979260	9.500481	10.499519	26
35	9.455469	9.981549	9.473919	10.526081	9.480140	9.979220	9.500920	10.499080	25
36	9.455893	9.981512	9.474381	10.525619	9.480539	9.979180	9.501359	10.498641	24
37	9.456316	9.981474	9.474842	10.525158	9.480937	9.979140	9.501797	10.498203	23
38	9.456739	9.981436	9.475303	10.524697	9.481334	9.979100	9.502235	10.497765	22
39	9.457162	9.981399	9.475763	10.524237	9.481731	9.979059	9.502672	10.497328	21
40	9.457584	9.981361	9.476223	10.523777	9.482128	9.979019	9.503109	10.496891	20
41	9.458006	9.981323	9.476683	10.523317	9.482525	9.978979	9.503546	10.496454	19
42	9.458427	9.981285	9.477142	10.522858	9.48292	9.978939	9.503982	10.496018	18
43	9.458848	9.981247	9.477601	10.522399	9.483316	9.978898	9.504418	10.495582	17
44	9.459268	9.981209	9.478059	10.521941	9.483712	9.978858	9.504854	10.495146	16
45	9.459688	9.981171	9.478517	10.521483	9.484107	9.978817	9.505289	10.494711	15
46	9.460108	9.981133	9.478975	10.521025	9.484501	9.978777	9.505724	10.494276	14
47	9.460527	9.981095	9.479432	10.520568	9.484895	9.978737	9.506159	10.493841	13
48	9.460946	9.981057	9.479886	10.520111	9.485289	9.978696	9.506593	10.493407	12
49	9.461364	9.981019	9.480345	10.519655	9.485682	9.978655	9.507027	10.492973	11
50	9.461782	9.980981	9.480801	10.519199	9.486075	9.978615	9.507460	10.492540	10
51	9.462199	9.980942	9.481257	10.518743	9.486467	9.978574	9.507892	10.492107	9
52	9.462616	9.980904	9.481712	10.518288	9.486860	9.978533	9.508326	10.491674	8
53	9.463032	9.980866	9.482167	10.517833	9.487251	9.978493	9.508759	10.491241	7
54	9.463448	9.980827	9.482621	10.517379	9.487643	9.978452	9.509191	10.490809	6
55	9.463864	9.980789	9.483075	10.516925	9.488034	9.978411	9.509622	10.490378	5
56	9.464279	9.980750	9.483529	10.516471	9.488424	9.978370	9.510054	10.489946	4
57	9.464694	9.980712	9.483982	10.516018	9.488814	9.978329	9.510485	10.489515	3
58	9.465108	9.980673	9.484435	10.515565	9.489204	9.978288	9.510916	10.489084	2
59	9.465522	9.980635	9.484887	10.515113	9.489593	9.978247	9.511346	10.488654	1
60	9.465935	9.980596	9.485339	10.514661	9.489982	9.978206	9.511776	10.488224	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang.	Tangent	M
	Degree 73.				Degree 72.				

	Degree 18.				Degree 19.				
M	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.489982	9.978206	9.511776	10.488224	9.512642	9.975670	9.536972	10.463028	60
1	9.490371	9.978165	9.512206	10.487794	9.513009	9.975627	9.537382	10.462618	59
2	9.490759	9.978124	9.512635	10.487365	9.513375	9.975583	9.537792	10.462208	58
3	9.491147	9.978083	9.513064	10.486936	9.513741	9.975539	9.538202	10.461798	57
4	9.491535	9.978042	9.513493	10.486507	9.514107	9.975496	9.538611	10.461389	56
5	9.491922	9.978001	9.513921	10.486079	9.514472	9.975452	9.539020	10.460980	55
6	9.492308	9.977959	9.514349	10.485651	9.514837	9.975408	9.539429	10.460571	54
7	9.492695	9.977918	9.514777	10.485223	9.515202	9.975365	9.539837	10.460163	53
8	9.493081	9.977877	9.515204	10.484796	9.515566	9.975321	9.546245	10.459755	52
9	9.493466	9.977835	9.515631	10.434369	9.515930	9.975277	9.540653	10.459347	51
10	9.493851	9.977794	9.516057	10.483943	9.516294	9.975233	9.541061	10.458939	50
11	9.494236	9.977752	9.516484	10.483516	9.516657	9.975189	9.541468	10.458532	49
12	9.494621	9.977711	9.516910	10.483096	9.517020	9.975145	9.541875	10.458125	48
13	9.495005	9.977669	9.517335	10.482665	9.517382	9.975101	9.542281	10.457719	47
14	9.495388	9.977628	9.517761	10.482239	9.517745	9.975057	9.542688	10.457312	46
15	9.495772	9.977586	9.518186	10.481814	9.518107	9.975013	9.543094	10.456906	45
16	9.496154	9.977544	9.518610	10.481390	9.518468	9.974969	9.543499	10.456501	44
17	9.496537	9.977503	9.519034	10.480966	9.518829	9.974925	9.543905	10.456095	43
18	9.496919	9.977461	9.519458	10.480542	9.519190	9.974880	9.544310	10.455690	42
19	9.497301	9.977419	9.519882	10.480118	9.519551	9.974836	9.544715	10.455285	41
20	9.497682	9.977377	9.520305	10.479695	9.519911	9.974792	9.545119	10.454881	40
21	9.498064	9.977335	9.520728	10.479272	9.520271	9.974748	9.545524	10.454476	39
22	9.498444	9.977293	9.521151	10.478849	9.520631	9.974703	9.545928	10.454072	38
23	9.498825	9.977251	9.521573	10.478427	9.520990	9.974659	9.546331	10.453669	37
24	9.499204	9.977209	9.521995	10.478005	9.521349	9.974614	9.546735	10.453265	36
25	9.499584	9.977167	9.522417	10.477583	9.521707	9.974570	9.547138	10.452862	35
26	9.499963	9.977125	9.522838	10.477162	9.522066	9.974525	9.547540	10.452460	34
27	9.500342	9.977083	9.523259	10.476741	9.522424	9.974481	9,547943	10.452057	33
28	9.500721	9.977041	9.523680	10.476320	9.522781	9.974436	9.548345	10.441655	32
29	9.501099	9.976999	9.524100	10.475900	9.523138	9.974391	9.548747	10.451253	31
30	9.501476	9.976957	9.524520	10.475480	9.523495	9.974347	9.549149	10.450851	30
31	9.501854	9.976914	9.524940	10.475060	9.523852	9.974302	9.549550	10.450450	29
32	9.502231	9.976872	9.525359	10.474641	9.524208	9.974257	9.549951	10.450049	28
33	9.502607	9.976830	9.525778	10.474222	9.524564	9.974212	9.550352	10.449648	27
34	9.502984	9.976787	9.526197	10.473803	9.524920	9.974167	9.550752	10.449248	26
35	9.503360	9.976745	9.526615	10.473385	9.525275	9.974122	9.551153	10.448847	25
36	9.503735	9.976702	9.527033	10.472967	9.525630	9.974077	9.551552	10.448448	24
37	9.504110	9.976660	9.527451	10.472549	9.525984	9.974032	9.551952	10.448048	23
38	9.504485	9.976617	9.527868	10.472132	9.526339	9.973987	9.552351	10.447649	22
39	9.504860	9.976574	9.528285	10.471715	9.526693	9.973942	9.552750	10.447250	21
40	9.505234	9.976532	9.528702	10.471298	9.527046	9.973897	9.553149	10.446851	20
41	9.505608	9.976489	9.529119	10.470881	9.527400	9.973852	9.553548	10.446452	19
42	9.505981	9.976446	9.529535	10.470465	9.527753	9.973808	9.553946	10.446054	18
43	9.506354	9.976404	9.529951	10.470049	9.528105	9.973761	9.554344	10.445656	17
44	9.506727	9.976361	9.530366	10.469634	9.528458	9.973716	9.554741	10.445259	16
45	9.507099	9.976318	9.530781	10.469219	9.528810	9.973671	9.555139	10.444861	15
46	9.507471	9.976275	9.531196	10.468804	9.529161	9.973625	9.555536	10.444464	14
47	9.507843	9.976232	9.531611	10.468389	9.529513	9.973580	9.555933	10.444067	13
48	9.508214	9.976185	9.532025	10.467975	9.529864	9.973535	9.556329	10.443671	12
49	9.508585	9.976146	9.532439	10.467561	9.530215	9.973489	9.556725	10.443275	11
50	9.508956	9.976103	9.532853	10.467147	9.530565	9.973444	9.557121	10.442879	10
51	9.509326	9.976060	9.533266	10.466734	9.530915	9.973398	9.557517	10.442483	9
52	9.509696	9.976017	9.533679	10.466321	9.531265	9.973352	9.557913	10.442087	8
53	9.510065	9.975973	9.534092	10.465908	9.531614	9.973307	9.558308	10.441692	7
54	9.510434	9.975930	9.534504	10.465496	9.531963	9.973261	9.558703	10.441297	6
55	9.510803	9.975887	9.534916	10.465084	9.532312	9.973215	9.559097	10.440903	5
56	9.511172	9.975844	9.535328	10.464672	9.532661	9.973169	9.559491	10.440509	4
57	9.511540	9.975800	9.535739	10.464261	9.533009	9.973124	9.559885	10.440115	3
58	9.511907	9.975757	9.536150	10.463850	9.533357	9.973078	9.550279	10.439721	2
59	9.512275	9.975713	9.536561	10.463439	9.533704	9.973032	9.550673	10.439327	1
60	9.512642	9.975670	9.536972	10.463028	9.534052	9.972986	9.551066	10.438934	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine.	Sine	Co-tang.	Tangent	M
	Degree 71.				Degree 70.				

A Table of Artificial Sines and Tangents.

Degree 20.				
M	Sine	Co-sine.	Tangent	Co-tang.
0	9.534052	9.972986	9.561066	10.438934
1	9.534399	9.972940	9.561459	10.438541
2	9.534745	9.972894	9.561851	10.438149
3	9.535092	9.972848	9.562244	10.437756
4	9.535438	9.972802	9.562636	10.437364
5	9.535783	9.972755	9.563028	10.436972
6	9.536129	9.972709	9.563419	10.436581
7	9.536474	9.972663	9.563811	10.436189
8	9.536818	9.972617	9.564202	10.435798
9	9.537163	9.972570	9.564593	10.435407
10	9.537507	9.972524	9.564983	10.435017
11	9.537851	9.972478	9.565373	10.434627
12	9.538194	9.972431	9.565763	10.434237
13	9.438537	9.972385	9.566153	10.433847
14	9.538880	9.972338	9.566542	10.433458
15	9.539223	9.972291	9.566932	10.433068
16	9.539565	9.972245	9.567320	10.432680
17	9.539907	9.972198	9.567709	10.432291
18	9.540249	9.972151	9.568098	10.431902
19	9.540590	9.972105	9.568486	10.431514
20	9.540931	9.972058	9.568873	10.431127
21	9.541272	9.972011	9.569261	10.430739
22	9.541613	9.971964	9.569648	10.430352
23	9.541953	9.971917	9.570035	10.429965
24	9.542293	9.971870	9.570422	10.429578
25	9.542632	9.971823	9.570809	10.429191
26	9.542971	9.971776	9.571195	10.428805
27	9.543310	9.971729	9.571581	10.428419
28	9.543649	9.971682	9.571967	10.428033
29	9.543987	9.971635	9.572352	10.427648
30	9.544325	9.971588	9.572738	10.427262
31	9.544663	9.971540	9.573123	10.426877
32	9.545000	9.971493	9.573507	10.426493
33	9.545338	9.971446	9.573892	10.426108
34	9.545674	9.971398	9.574276	10.425724
35	9.546011	9.971351	9.574660	10.425340
36	9.546347	9.971303	9.575044	10.424956
37	9.546683	9.971256	9.575427	10.424573
38	9.547019	9.971208	9.575810	10.424190
39	9.547354	9.971161	9.576193	10.423807
40	9.547689	9.971113	9.576576	10.423424
41	9.548024	9.971066	9.576959	10.423041
42	9.548359	9.971018	9.577341	10.422659
43	9.548693	9.970970	9.577723	10.422277
44	9.549027	9.970922	9.578104	10.421896
45	9.549360	9.970874	9.578486	10.421514
46	9.549693	9.970827	9.578867	10.421133
47	9.550026	9.970779	9.579248	10.420752
48	9.550359	9.970731	9.579629	10.420371
49	9.550692	9.970683	9.580009	10.419991
50	9.551024	9.970635	9.580389	10.419611
51	9.551356	9.970586	9.580769	10.419231
52	9.551687	9.970538	9.581149	10.418851
53	9.552018	9.970490	9.581528	10.418472
54	9.552349	9.970442	9.581907	10.418093
55	9.552680	9.970394	9.582286	10.417714
56	9.553010	9.970345	9.582665	10.417335
57	9.553342	9.970297	9.583043	10.416956
58	9.553670	9.970249	9.583422	10.416578
59	9.554000	9.970200	9.583800	10.416200
60	9.554329	9.970152	9.584177	10.415823
	Co-sine	Sine	Co-tang.	Tangent
Degree 69.				

Degree 21.				
Sine	Co-sine	Tangent	Co-tang.	
9.554329	9.970152	9.584177	10.415823	60
9.554658	9.970103	9.584555	10.415445	59
9.554987	9.970055	9.584932	10.415068	58
9.555315	9.970006	9.585309	10.414691	57
9.555643	9.969957	9.585686	10.414314	56
9.555971	9.969909	9.586062	10.413938	55
9.556299	9.969860	9.586439	10.413561	54
9.556626	9.969811	9.586815	10.413185	53
9.556953	9.969762	9.587190	10.412810	52
9.557280	9.969714	9.587566	10.412434	51
9.557606	9.960665	9.587941	10.412059	50
9.557932	9.969616	9.588316	10.411684	49
9.558258	9.969567	9.588691	10.411309	48
9.558583	9.969518	9.589006	10.410934	47
9.558909	9.969469	9.589440	10.410560	46
9.559234	9.969420	9.589814	10.410186	45
9.559558	9.969370	9.590188	10.409812	44
9.559883	9.969321	9.590562	10.409438	43
9.560207	9.969272	9.590935	10.409065	42
9.560531	9.969223	9.591308	10.408692	41
9.560855	9.969173	9.591681	10.408319	40
9.561178	9.969124	9.592054	10.407946	39
9.561501	9.969075	9.592426	10.407574	38
9.561824	9.969025	9.592799	10.407201	37
9.562146	9.968976	9.593171	10.406829	36
9.562468	9.968926	9.593542	10.406458	35
9.562790	9.968877	9.593914	10.406086	34
9.563112	9.968827	9.594285	10.405715	33
9.563433	9.968777	9.594656	10.405344	32
9.563755	9.968728	9.595027	10.404973	31
9.564075	9.968678	9.595398	10.404602	30
9.564396	9.968628	9.595768	10.404232	29
9.564716	9.968578	9.596138	10.403862	28
9.565036	9.968528	9.596508	10.403492	27
9.565356	9.968479	9.596878	10.403122	26
9.565676	9.968429	9.597247	10.402753	25
9.565995	9.968379	6.597616	10.402384	24
9.566314	9.968329	9.597985	10.402015	23
9.566632	9.968278	9.598354	10.401646	22
9.566951	9.968228	9.598722	10.401278	21
9.567269	9.968178	9.599091	10.400909	20
9.567587	9.968128	9.599459	10.400541	19
9.567904	9.968078	9.599827	10.400173	18
9.568222	9.968027	9.600194	10.399806	17
9.568539	9.967977	9.600562	10.399438	16
9.568856	9.967927	9.600929	10.399071	15
9.569172	9.967876	9.601296	10.398704	14
9.569488	9.967826	9.601663	10.398337	13
9.569804	9.967775	9.602029	10.397971	12
9.570120	9.967725	9.602395	10.397605	11
9.570435	9.967674	9.602761	10.397239	10
9.570751	9.967624	9.603127	10.396873	9
9.571066	9.967573	9.603493	10.396507	8
9.571380	9.967522	9.603858	10.396142	7
9.571695	9.967471	9.604223	10.395777	6
9.572009	9.967421	9.604588	10.395412	5
9.572323	9.967370	9.604953	10.395047	4
9.572636	9.967319	9.605317	10.394683	3
9.572950	9.967268	9.605682	10.394318	2
9.573263	9.967217	9.606046	10.393954	1
9.573575	9.967166	9.606410	10.393590	0
Co-sine.	Sine	Co-tang.	Tangent	M
Degree 68.				

A Table of Artificial Sines and Tangents.

M	Degree 22. Sine	Co-sine	Tangent	Co-tang.	Degree 23. Sine	Co-sine	Tangent	Co-tang.	
0	9.573575	9.967166	9.606410	10.393590	9.591878	9.964026	9.627852	10.372148	60
1	9.573888	9.967115	9.606773	10.393227	9.592176	9.963972	9.628203	10.371797	59
2	9.574200	9.967064	9.607136	10.392863	9.592473	9.963919	9.628554	10.371446	58
3	9.574512	9.967013	9.607500	10.392500	9.592770	9.963865	9.628905	10.371095	57
4	9.574824	9.966961	9.607863	10.392137	9.593067	9.963811	9.629255	10.370745	56
5	9.575136	9.966910	9.608225	10.391775	9.593363	9.963757	9.629606	10.370394	55
6	9.575447	9.966859	9.608588	10.391412	9.593659	9.963704	9.629956	10.370044	54
7	9.575758	9.966808	9.608950	10.391050	9.593955	9.963650	9.630306	10.369694	53
8	9.576069	9.966756	9.609312	10.390688	9.594251	9.963596	9.630656	10.369344	52
9	9.576379	9.966705	9.609674	10.390326	9.594547	9.963542	9.631005	10.368995	51
10	9.576689	9.966653	9.610036	10.389964	9.594842	9.963488	9.631355	10.368645	50
11	9.576999	9.966602	9.610397	10.389603	9.595137	9.963434	9.631704	10.368296	49
12	9.577309	9.966550	9.610759	10.389241	9.595432	9.963379	9.632053	10.367947	48
13	9.577618	9.966499	9.611120	10.388880	9.595727	9.963325	9.632402	10.367598	47
14	9.577927	9.966447	9.611480	10.388520	9.596021	9.963271	9.632750	10.367250	46
15	9.578236	9.966395	9.611841	10.388159	9.596315	9.963217	9.633099	10.366901	45
16	9.578545	9.966344	9.612201	10.387799	9.596609	9.963163	9.633447	10.366553	44
17	9.578853	9.966292	9.612561	10.387439	9.596903	9.963108	9.633795	10.366205	43
18	9.579162	9.966240	9.612921	10.387079	9.597196	9.963054	9.634143	10.365857	42
19	9.579469	9.966188	9.613281	10.386719	9.597490	9.962999	9.634490	10.365510	41
20	9.579777	9.966136	9.613641	10.386359	9.597783	9.962945	9.634838	10.365162	40
21	9.580084	9.966085	9.614000	10.386000	9.598075	9.962890	9.635185	10.364815	39
22	9.580392	9.966033	9.614359	10.385641	9.598368	9.962836	9.635532	10.364468	38
23	9.580699	9.965981	9.614718	10.385282	9.598660	9.962781	9.635879	10.364121	37
24	9.581005	9.965929	9.615077	10.384923	9.598952	9.962727	9.636226	10.363774	36
25	9.581312	9.965876	9.615435	10.384565	9.599244	9.962672	9.636572	10.363428	35
26	9.581618	9.965824	9.615793	10.384207	9.599536	9.962617	9.636919	10.363081	34
27	9.581924	9.965772	9.616151	10.383849	9.599827	9.962562	9.637265	10.362735	33
28	9.582229	9.965720	9.616509	10.383491	9.600118	9.962508	9.637611	10.362389	32
29	9.582535	9.965668	9.616867	10.383133	9.600409	9.962453	9.637956	10.362044	31
30	9.582840	9.965615	9.617224	10.382776	9.600700	9.962398	9.638302	10.361698	30
31	9.583145	9.965563	9.617582	10.382418	9.600990	9.962343	9.638647	10.361353	29
32	9.583449	9.965511	9.617939	10.382061	9.601280	9.962288	9.638992	10.361008	28
33	9.583754	9.965458	9.618295	10.381705	9.601570	9.962233	9.639337	10.360663	27
34	9.584058	9.965406	9.618652	10.381348	9.601860	9.962178	9.639682	10.360318	26
35	9.584361	9.965353	9.619008	10.380992	9.602150	9.962123	9.640027	10.359973	25
36	9.584665	9.965301	9.619364	10.380635	9.602439	9.962067	9.640371	10.359629	24
37	9.584968	9.965248	9.619720	10.380280	9.602728	9.962012	9.640716	10.359284	23
38	9.585271	9.965195	9.620076	10.379924	9.603017	9.961957	9.641060	10.358940	22
39	9.585574	9.965143	9.620432	10.379568	9.603305	9.961902	9.641404	10.358596	21
40	9.585877	9.965090	9.620787	10.379213	9.603594	9.961846	9.641747	10.358253	20
41	9.586179	9.965037	9.621142	10.378858	9.603882	9.961791	9.642091	10.357909	19
42	9.586482	9.964984	9.621497	10.378503	9.604170	9.961735	9.642434	10.357566	18
43	9.586783	9.964931	9.621852	19.378148	9.604457	9.961680	9.642777	10.357223	17
44	9.587085	9.964879	9.622206	10.377793	9.604745	9.961624	9.643120	10.356880	16
45	9.587386	9.964826	9.622561	10.377439	9.605032	9.961569	9.643463	10.356537	15
46	9.587688	9.964773	9.622915	10.377085	9.605319	9.961513	9.643806	10.356194	14
47	9.587989	9.964720	9.623269	10.376731	9.605606	9.961458	9.644148	10.355852	13
48	9.588289	9.964666	9.623623	10.376377	9.605892	9.961402	9.644490	10.355510	12
49	9.588590	9.964613	9.623976	10.376024	9.606179	9.961346	9.644832	10.355168	11
50	9.588890	9.964560	9.624330	10.375670	9.606465	9.961290	9.645174	10.354826	10
51	9.589190	9.964507	9.624683	10.375317	9.606751	9.961235	9.645516	10.354484	9
52	9.589489	9.964454	9.625036	10.374964	9.607036	9.961179	6.645857	10.354143	8
53	9.589789	9.964400	9.625388	10.374612	9.607322	9.961123	9.646199	10.353801	7
54	9.590088	9.964347	9.625741	10.374259	9.607607	9.961067	9.646540	10.353460	6
55	9.590387	9.964294	9.626093	10.373907	9.607892	9.961011	9.646881	10.353119	5
56	9.590686	9.964240	9.626445	10.373555	9.608177	9.960955	9.647222	10.352778	4
57	9.590984	9.964187	9.626797	10.373203	9.608461	9.960899	9.647562	10.352438	3
58	9.591282	9.964133	9.627149	10.372851	9.608745	9.960843	9.647903	10.352097	2
59	9.591580	9.964080	9.627501	10.372499	9.609029	9.960786	9.648243	10.351757	1
60	9.591878	9.964026	9.627852	10.372148	9.609313	9.960730	9.648583	10.351417	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang.	Tangent	M
	Degree 67.				Degree 66.				

	Degree 24.				Degree 25.				
M	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.609313	9.960730	9.648583	10.351417	9.625948	9.957276	9.668673	10.331327	60
1	9.609597	9.960674	9.648923	10.351077	9.626219	9.957217	9.669002	10.330998	59
2	9.609880	9.960617	9.649263	10.350737	9.626490	9.957158	9.669332	10.330668	58
3	9.610164	9.960561	9.649602	10.350398	9.626760	9.957099	9.669661	10.330339	57
4	9.610447	9.960505	9.649942	10.350058	9.627030	9.957040	9.669991	10.330009	56
5	9.610729	9.960448	9.650281	10.349719	9.627300	9.956981	9.670320	10.329680	55
6	9.611012	9.960392	9.650620	10.349380	9.627570	9.956921	9.670649	10.329351	54
7	9.611294	9.960335	9.650959	10.349041	9.627840	9.956862	9.670977	10.329023	53
8	9.611576	9.960279	9.651297	10.348703	9.628109	9.956803	9.671306	10.328694	52
9	9.611858	9.960222	9.651636	10.348364	9.628378	9.956744	9.671635	10.328365	51
10	9.612140	9.960165	9.651974	10.348026	9.628647	9.956684	9.671963	10.328037	50
11	9.812421	9.960109	9.652312	10.347688	9.628916	9.956625	9.672291	10.327709	49
12	9.612702	9.960052	9.652650	10.347350	9.629185	9.956565	9.672619	10.327381	48
13	9.612983	9.959995	9.652988	10.347012	9.629453	9.956506	9.672947	10.327053	47
14	9.613264	9.959938	9.653326	10.346674	9.929721	9.956447	9.673274	10.326726	46
15	9.613545	9.959881	9.653663	10.346337	9.629989	9.956387	9.673602	10.326398	45
16	9.613825	9.959825	9.654000	10.346000	9.630257	9.956327	9.673929	10.326071	44
17	9.614105	9.959768	9.654337	10.345663	9.630524	9.956268	9.674257	10.325743	43
18	9.614385	9.959711	9.654674	10.345326	9.630792	9.956208	9.674584	10.325416	42
19	9.614665	9.959654	9.655011	10.344989	9.631059	9.956148	9.674911	10.325089	41
20	9.614944	9.959596	9.655348	10.344652	9.631326	9.956089	9.675237	10.324763	40
21	9.615223	9.959539	9.655684	10.344316	9.631593	9.956029	9.675564	10.324436	39
22	9.615502	9.959482	9.656020	10.343980	9.631859	9.955969	9.675890	10.324110	38
23	9.615781	9.959425	9.656356	10.343644	9.632125	9.955909	9.676217	10.323783	37
24	9.616060	9.959368	9.656692	10.343308	9.632392	9.955849	9.676543	10.323457	36
25	9.616338	9.959310	9.657028	10.342972	9.632658	9.955789	9.676869	10.323131	35
26	9.616616	9.959253	9.657364	10.342636	9.632923	9.955729	9.677194	10.322806	34
27	9.616894	9.959195	9.657699	10.342301	9.633189	9.955669	9.677520	10.322480	33
28	9.617172	9.959138	9.658034	10.341966	9.633454	9.955669	9.677846	10.322154	32
29	9.617450	9.959080	9.658369	10.341631	9.633719	9.955548	9.678171	10.321829	31
30	9.617727	9.959023	9.658704	10.341296	9.633984	9.955488	9.678496	10.321504	30
31	9.618004	9.958965	9.659039	10.340961	9.634249	9.955428	9.678821	10.321179	29
32	9.618281	9.958908	9.659373	10.340627	9.634514	9.955368	9.679146	10.320854	28
33	9.618558	9.958850	9.659708	10.340292	9.634778	9.955307	9.679471	10.320529	27
34	9.618834	9.958792	9.660042	10.339958	9.635042	9.955247	9.679795	10.320205	26
35	9.619110	9.958734	9.660376	10.339624	9.635306	9.955186	9.680120	10.319880	25
36	9.619386	9.958677	9.660710	10.339290	9.635570	9.955126	9.680444	10.319556	24
37	9.619662	9.958619	9.661043	10.338957	9.635834	9.955065	9.680768	10.319232	23
38	9.619938	9.958561	9.661377	10.338623	9.636097	9.955005	9.681092	10.318908	22
39	9.620213	9.958503	9.661710	10.338290	9.636360	9.954944	9.681416	10.318584	21
40	9.620488	9.958445	9.662043	10.337957	9.636623	9.954883	9.681740	10.318260	20
41	9.620763	9.958387	9.662376	10.337624	9.636886	9.954823	9.682063	10.317937	19
42	9.621038	9.958329	9.662709	10.337291	9.637148	9.954762	9.682387	10.317613	18
43	9.621313	9.958271	9.663042	10.336958	9.637411	9.954701	9.682710	10.317290	17
44	9.621587	9.958213	9.663375	10.336625	9.637673	9.954640	9.683033	10.316967	16
45	9.621861	9.958154	9.663707	10.336293	9.637935	9.954579	9.683356	10.316644	15
46	9.622135	9.958096	9.664039	10.335961	9.638197	9.954518	9.683679	10.316321	14
47	9.622409	9.958038	9.664371	10.335629	9.638458	9.954457	9.684001	10.315999	13
48	9.622682	9.957979	9.664703	10.335297	9.638720	9.954396	9.684324	10.315676	12
49	9.622956	9.957921	9.665035	10.334965	9.638981	9.954335	9.684646	10.315354	11
50	9.623229	9.957863	9.665366	10.334634	9.639242	9.954274	9.684968	10.315032	10
51	9.623502	9.957804	9.665698	10.334302	9.639503	9.954213	9.685290	10.314710	9
52	9.623774	9.957746	9.666029	10.333971	9.639764	9.954152	9.685612	10.314388	8
53	9.624047	9.957687	9.666360	10.333640	9.640024	9.954090	6.685934	10.314066	7
54	9.624319	9.957628	9.666691	10.333309	9.640284	9.954029	9.686255	10.313745	6
55	9.624591	9.957570	9.667021	10.332979	9.640544	9.953968	9.686577	10.313423	5
56	9.624863	9.957511	9.667352	10.332648	9.640804	9.953906	9.686898	10.313102	4
57	9.625135	9.957452	9.667682	10.332318	9.641064	9.953845	9.687219	10.312781	3
58	9.625406	9.957393	9.668013	10.331987	9.641324	9.953783	9.687540	10.312460	2
59	9.625677	9.957335	9.668343	10.331657	9.641583	9.953722	9.687861	10.312139	1
60	9.625948	9.957276	9.668673	10.331327	9.641842	9.953660	9.688182	10.311818	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang.	Tangent	M
	Degree 65.				Degree 64.				

Degree 26.

M	Sine	Co-fine.	Tangent	Co-tang.
0	9.641842	9.953660	9.688182	10.311818
1	9.642101	9.953599	9.688502	10.311498
2	9.642360	9.953537	9.688823	10.311177
3	9.642618	9.953475	9.689143	10.310857
4	9.642877	9.953413	9.689463	10.310537
5	9.643135	9.953352	9.689783	10.310217
6	9.643393	9.953290	9.690103	10.309897
7	9.643650	9.953228	9.690423	10.309577
8	9.643908	9.953166	9.690742	10.309258
9	9.644165	9.953104	9.691062	10.308938
10	9.644423	9.953042	9.691381	10.308619
11	9.644680	9.952980	9.691700	10.308300
12	9.644936	9.952918	9.692019	10.307981
13	9.645193	9.952855	9.692338	10.307662
14	9.645450	9.952793	9.692656	10.307344
15	9.645706	9.952731	9.692975	10.307025
16	9.645962	9.952669	9.693293	10.306707
17	9.646218	9.952606	9.693612	10.306388
18	9.646474	9.952544	9.693930	10.306070
19	9.646729	9.952481	9.694248	10.305752
20	9.646984	9.952419	9.694566	10.305434
21	9.647240	9.952356	9.694883	10.305117
22	9.647494	9.952294	9.695201	10.304799
23	9.647749	9.952231	9.695518	10.304482
24	9.648004	9.952168	9.695836	10.304164
25	9.648258	9.952106	9.696153	10.303847
26	9.648512	9.952043	9.696470	10.303530
27	9.648766	9.951980	9.696787	10.303213
28	9.649020	9.951917	9.697103	10.302897
29	9.649274	9.951854	9.697420	10.302580
30	9.649527	9.951791	9.697736	10.302264
31	9.649781	9.951728	9.698053	10.301947
32	9.650034	9.951665	9.698369	10.301631
33	9.650287	9.951602	9.698685	10.301315
34	9.650539	9.951539	9.699001	10.300999
35	9.650792	9.951476	9.699316	10.300684
36	9.651044	9.951412	9.699632	10.300368
37	9.651297	9.951349	9.699947	10.300052
38	9.651549	9.951286	9.700263	10.299737
39	9.651800	9.951122	9.700578	10.299422
40	9.652052	9.951159	9.700893	10.299107
41	9.652304	9.951096	9.701208	10.298792
42	9.652555	9.951032	9.701523	10.298477
43	9.652806	9.950968	9.701837	10.298163
44	9.653057	9.950905	9.702152	10.297848
45	9.653308	9.950841	9.702466	10.297534
46	9.653558	9.950778	9.702781	10.297219
47	9.653808	9.950714	9.703095	10.296905
48	9.654059	9.950650	9.703409	10.296591
49	9.654309	9.950586	9.703722	10.296278
50	9.654558	9.950522	9.704036	10.295964
51	9.654808	9.950458	9.704350	10.295650
52	9.645058	9.950394	9.704663	10.295337
53	9.655307	9.950330	9.704976	10.295024
54	9.655556	9.950266	9.705290	10.294710
55	9.655805	9.950202	9.705603	10.294397
56	9.656054	9.950138	9.705916	10.294084
57	9.656302	9.950074	9.706228	10.293772
58	9.656551	9.950010	9.706541	10.293459
59	9.656799	9.949995	9.706854	10.293146
60	9.657047	9.949881	9.707166	10.292834
	Co-fine	Sine	Co-tang.	Tangent

Degree 63.

Degree 27.

Sine	Co-fine	Tangent	Co-tang.	
9.657047	9.949881	9.707166	10.292834	60
9.657295	9.949816	9.707478	10.292522	59
9.657542	9.949752	9.707790	10.292210	58
9.657790	9.949688	9.708102	10.291898	57
9.658037	9.949623	9.708414	10.291586	56
9.658284	9.949558	9.708726	10.291274	55
9.658531	9.949494	9.709037	10.290063	54
9.658778	9.949429	9.709349	10.290651	53
9.659025	9.949364	9.709660	10.290340	52
9.659271	9.949300	9.709971	10.290029	51
9.659517	9.949235	9.710282	10.289718	50
9.659763	9.949170	9.710593	10.289407	49
9.660009	9.949105	9.710904	10.289096	48
9.660255	9.940040	9.711215	10.288785	47
9.660501	9.948975	9.711525	10.288475	46
9.660746	9.948910	9.711836	10.288164	45
9.660991	9.948845	9.712146	10.287854	44
9.661236	9.948780	9.712456	10.287544	43
9.661481	9.948715	9.712766	10.287234	42
9.661726	9.948650	9.713076	10.286924	41
9.661970	9.948584	9.713386	10.286614	40
9.662214	9.948519	9.713696	10.286305	39
9.662459	9.948454	9.714005	10.285995	38
9.662703	9.948388	9.714314	10.285686	37
9.662946	9.948323	9.714624	10.285376	36
9.663190	9.948257	9.714933	10.285067	35
9.663433	9.948192	9.715242	10.284758	34
9.663677	9.948126	9.715551	10.284449	33
9.663920	9.948060	9.715860	10.284140	32
9.664163	9.947995	9.716168	10.283832	31
9.664406	9.947929	9.716477	10.283523	30
9.664648	9.947863	9.716785	10.283215	29
9.664891	9.947797	9.717093	10.282907	28
9.664133	9.947731	9.717401	10.282599	27
9.665375	9.947665	9.717709	10.282291	26
9.665617	9.947600	9.718017	10.281983	25
9.665859	9.947533	9.718325	10.281675	24
9.666100	9.947467	9.718633	10.281367	23
9.666342	9.947401	9.718940	10.281060	22
9.666583	9.947335	9.719248	10.280752	21
9.666824	9.947269	9.719555	10.280445	20
9.667065	9.947203	9.719862	10.280138	19
9.667305	9.947136	9.720169	10.279831	18
9.667546	9.947070	9.720476	10.279524	17
9.667786	9.947004	9.720783	10.279217	16
9.668027	9.946937	9.721089	10.278911	15
9.668267	9.946871	9.721396	10.278604	14
9.668506	9.946804	9.721702	10.278298	13
9.668746	9.946738	9.722009	10.277991	12
9.668986	9.946671	9.722315	10.277685	11
9.669225	9.946604	9.722621	10.277379	10
9.669464	9.946538	9.722927	10.277073	9
9.669703	9.946471	9.723232	10.276768	8
9.669942	9.946404	9.723538	10.276462	7
9.670181	9.946337	9.723844	10.276156	6
9.670419	9.946270	9.724149	10.275851	5
9.670658	9.946203	9.724454	10.275546	4
9.670896	9.946136	9.724760	10.275240	3
9.671134	9.946069	9.725065	10.274935	2
9.671372	9.946002	9.725370	10.274630	1
9.671609	9.945935	9.725674	10.274326	0
Co-fine.	Sine	Co-tang.	Tangent	M

Degree 62.

	Degree 28.				Degree 29.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.671609	9.945935	9.725674	10.274326	9.685571	9.941819	9.743751	10.256248	60
1	9.671847	9.945868	9.725979	10.274021	9.685799	9.941749	9.744050	10.255950	59
2	9.672084	9.945800	9.726284	10.273716	9.686027	9.941679	9.744348	10.255652	58
3	9.672321	9.945733	9.727588	10.273412	9.686254	9.941609	9.744645	10.255355	57
4	9.672558	9.945666	9.726892	10.273108	9.686482	9.941539	9.744943	10.255057	56
5	9.672795	9.945598	9.727197	10.272803	9.686709	9.941469	9.745240	10.254760	55
6	9.673032	9.945531	9.727501	10.272499	9.686936	9.941398	9.745538	10.254462	54
7	9.673268	9.945464	9.727805	10.272195	9.687163	9.941328	9.745835	10.254165	53
8	9.673505	9.945396	9.728109	10.271891	9.687389	9.941258	9.746132	10.253868	52
9	9.673741	9.945328	9.728412	10.271588	9.687616	9.941187	9.746429	10.253571	51
10	9.673977	9.945261	9.728716	10,271284	9.687843	9.941117	9.746726	10.253274	50
11	9.674213	9.945193	9.729020	10.270980	9.688069	9.941046	9.747023	10.252977	49
12	9.674448	9.945125	9.729323	10.270677	9.688295	9.940975	9.747319	10.252681	48
13	9.674684	9.945058	9.729626	10.270374	9.688521	9.940905	9.747616	10.252384	47
14	9.674919	9.944990	9.729929	10.270071	9.688747	9.940834	9.747913	10.252087	46
15	9.675155	9.944922	9.730233	10.269767	9.688972	9.940763	9.748209	10.251791	45
16	9.675390	9.944854	9.730535	10.269465	9.689198	9.940693	9.748505	10,251495	44
17	9.675624	9.944786	9.730838	10.269162	9.689423	9.940622	9.748801	10.251199	43
18	9.675859	9.944718	9.731141	10.268859	9.689648	9.940551	9.749097	10.250903	42
19	9.676094	9.944650	9.731444	10.268556	9.689873	9.940480	9.749393	10.250607	41
20	9.676328	9.944582	9.731746	10.268254	9.690098	9.940409	9.749689	10.250311	40
21	9.676562	9.944514	9.732048	10.267952	9.690323	9.940338	9.749985	10.250015	39
22	9.676796	9.944446	9.732351	10.267649	9.690548	9.940267	9.750281	10.249719	38
23	9.677030	9.944377	9.732653	10.267347	9.690772	9.940196	9.750576	10.249424	37
24	9.677264	9.944309	9.732955	10.267045	9.690996	9.940125	9.750872	10.249128	36
25	9.677498	9.944241	9.733257	10.266743	9.691220	9.940053	9.751167	10.248833	35
26	9.677731	9.944172	9.733558	10.266442	9.691444	9.939982	9.751462	10.248538	34
27	9.677964	9.944104	9.733860	10.266140	9.691668	9.939911	9,751757	10.248243	33
28	9.678197	9.944036	9.734162	10.265838	9.691892	9.939840	9.752052	10.247948	32
29	9.678430	9.943967	9.734463	10.265537	9.692115	9.939768	9.752347	10.247653	31
30	9.678663	9.943899	9.734764	10.265236	9.692339	9.939697	9.752642	10.247358	30
31	9.678895	9.943830	9.735066	10.264934	9.692562	9.939625	9.752937	10.247063	29
32	9.679128	9.943761	9.735367	10.264633	9.692785	9.939554	9.753231	10.246769	28
33	9.679360	9.943693	9.735668	10.264332	9.693008	9.939482	9.753526	10.246474	27
34	9.679592	9.943624	9.735969	10.264031	9.693231	9.939410	9.753820	10.246180	26
35	9.679824	9.943555	9.736269	10.263731	9.693453	9.939339	9.754115	10.245885	25
36	9.680056	9.943486	9.736570	10.263430	9.693676	9.939267	9.754409	10.245591	24
37	9.680288	9.943417	9.736870	10.263130	9.693898	9.939195	9.754793	10.245297	23
38	9.680519	9.943348	9.737171	10.262829	9.694120	9.939123	9.754997	10.245003	22
39	9.680750	9.943279	9.737471	10.262529	9.694342	9.939052	9.755291	10.244709	21
40	9.680982	9.943210	9.737771	10.262229	9.694564	9.938980	9.755585	10.244415	20
41	9.681213	9.943141	9.738071	10.261629	9.694786	9.938908	9.755878	10.244122	19
42	9.681443	9.943072	9.738371	10.261629	9.695007	9.938836	9.756172	10.243828	18
43	9.681674	9.943003	9.738671	10.261329	9.695229	9.938763	9.756465	10.243535	17
44	9.681905	9.942934	9.738971	10.261029	9.695450	9.938691	9.756759	10.243241	16
45	9.682135	9.942864	9.739271	10.260729	9.695671	9.938619	9.757052	10.242948	15
46	9.682365	9.942795	9.739570	10.260430	9.695892	9.938547	9.757345	10.242655	14
47	9.682595	9.942726	9.739870	10.260130	9.696113	9.938475	9.757638	10.242362	13
48	9.682825	9.942656	9.740169	10.259831	9.696334	9.938402	9.757931	10.242069	12
49	9.683055	9.942587	9.740468	10.259532	9.696554	9.938330	9.758224	10.241776	11
50	9.683284	9.942517	9.740767	10.259233	9.696775	9.938258	9.758517	10.241483	10
51	9.683514	9.942448	9.741066	10.258934	9.696995	9.938185	9.758810	10.241190	9
52	9.683743	9.942378	9.741365	10.258635	9.697215	9.938113	9.759102	10.240898	8
53	9.683972	9.942308	9.741664	10.258336	9.697435	9.938040	9.759395	10.240605	7
54	9.684201	9.942239	9.741962	10.258038	9.697654	9.937967	9.759687	10.240313	6
55	9.684430	9.942169	9.742261	10.257739	9.697874	9.937895	9.759979	10.240021	5
56	9.684658	9.942099	9.742559	10.257441	9.698094	9.937822	9.760272	10.239728	4
57	9.684887	9.942029	9.742858	10.257142	9.698313	9.937749	9.760564	10.239436	3
58	9.685115	9.941959	9.743156	10.256844	9.698532	9.937676	9.760856	10.239144	2
59	9.685343	9.941889	9.743454	10.256546	9.698751	9.937604	9.761148	10.238852	1
60	9.685571	9.941819	9.743752	10.256248	9.698970	9.937531	9.761439	10.238561	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine.*	Sine	*Co-tang.*	Tangent	M
	Degree 61.				Degree 60.				

A Table of Artificial Sines and Tangents.

M	Degree 30.				Degree 31.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.698970	9.937531	9.761439	10.238561	9.711839	9.933066	9.778774	10.221226	60
1	9.699189	9.937458	9.761731	10.238269	9.712050	9.932990	9.779060	10.220940	59
2	9.699407	9.937385	9.762023	10.237977	9.712260	9.932914	9.779346	10.220654	58
3	9.699626	9.937312	9.762314	10.237686	9.712469	9.932838	9.779632	10.220368	57
4	9.699844	9.937238	9.762606	10.237394	9.712679	9.932762	9.779918	10.220082	56
5	9.700062	9.937165	9.762897	10.237103	9.712889	9.932685	9.780203	10.219797	55
6	9.700280	9.937092	9.763188	10.236812	9.713098	9.932609	9.780489	10.219511	54
7	9.700498	9.937019	9.763479	10.236521	9.713308	9.932533	9.780775	10.219225	53
8	9.700796	9.936946	9.763770	10.236230	9.713517	9.932457	9.781060	10.218940	52
9	9.700933	9.936872	9.764061	10.235939	9.713726	9.932380	9.781346	10.218654	51
10	9.701151	9.936799	9.764352	10.235648	9.713935	9.932304	9.781631	10.218369	50
11	9.701368	9.936725	9.764643	10.235357	9.714144	9.932228	9.781916	10.218084	49
12	9.701585	9.936652	9.764933	10.235067	9.714352	9.932151	9.782201	10.217799	48
13	9.701802	9.936578	9.765224	10.234776	9.714561	9.932075	9.782486	10.217514	47
14	9.702019	9.936505	9.765514	10.234486	9.714769	9.931998	9.782771	10.217229	46
15	9.702236	9.936431	9.765805	10.234195	9.714978	9.931921	9.783056	10.216944	45
16	9.702452	9.936357	9.766095	10.233905	9.715186	9.931845	9.783341	10.216659	44
17	9.702669	9.936284	9.766385	10.233615	9.715394	9.931768	9.783626	10.216374	43
18	9.702885	9.936210	9.766675	10.233325	9.715602	9.931691	9.783910	10.216090	42
19	9.703101	9.936136	9.766965	10.233035	9.715809	9.931614	9.784195	10.215805	41
20	9.703317	9.936062	9.767255	10.232745	9.716017	9.931537	9.784479	10.215521	40
21	9.703533	9.935988	9.767545	10.232455	9.716224	9.931460	9.784764	10.215236	39
22	9.703749	9.935914	9.767834	10.232166	9.716432	9.931383	9.785048	10.214952	38
23	9.703964	9.935840	9.768124	10.231876	9.716639	9.931306	9.785332	10.214668	37
24	9.704179	9.935766	9.768414	10.231586	9.716846	9.931229	9.785616	10.214384	36
25	9.704395	9.935692	9.768703	10.231297	9.717053	9.931152	9.785900	10.214100	35
26	9.704610	9.935618	9.768992	10.231008	9.717259	9.931075	9.786184	10.213816	34
27	9.704825	9.935543	9.769281	10.230719	9.717466	9.930998	9.786468	10.213532	33
28	9.705040	9.935469	9.769571	10.230429	9.717673	9.930921	9.786752	10.213248	32
29	9.705254	9.935395	9.769860	10.230140	9.717879	9.930843	9.787036	10.212964	31
30	9.705469	9.935320	9.770148	10.229852	9.718085	9.930766	9.787319	10.212681	30
31	9.705683	9.935246	9.770437	10.229563	9.718291	9.930688	9.787603	10.212397	29
32	9.705898	9.935171	9.770726	10.229274	9.718497	9.930611	9.787886	10.212114	28
33	9.706112	9.935097	9.771015	10.228985	9.718703	9.930533	9.788170	10.211830	27
34	9.706326	9.935022	9.771303	10.228697	9.718909	9.930456	9.788453	10.211547	26
35	9.706539	9.934948	9.771592	10.228408	9.719114	9.930378	9.788736	10.211264	25
36	9.706753	9.934873	9.771880	10.228120	9.719320	9.930300	9.789019	10.210981	24
37	9.706967	9.934798	9.772168	10.227832	9.719525	9.930223	9.789302	10.210698	23
38	9.707180	9.934723	9.772457	10.227543	9.719730	9.930145	9.789585	10.210415	22
39	9.707393	9.934649	9.772745	10.227255	9.719935	9.930067	9.789868	10.210132	21
40	9.707606	9.934574	9.773033	10.226967	9.720140	9.929989	9.790151	10.209849	20
41	9.707819	9.934499	9.773321	10.226679	9.720345	9.929911	9.790434	10.209566	19
42	9.708032	9.934424	9.773608	10.226392	9.720549	9.929833	9.790716	10.209284	18
43	9.708245	9.934349	9.773896	10.226104	9.720754	9.929755	9.790999	10.209001	17
44	9.708458	9.934274	9.774184	10.225816	9.720958	9.929677	9.791281	10.208719	16
45	9.708670	9.934199	9.774471	10.225529	9.721162	9.929599	9.791563	10.208437	15
46	9.708882	9.934123	9.774759	10.225241	9.721366	9.929521	9.791846	10.208154	14
47	9.709094	9.934048	9.775046	10.224954	9.721570	9.929442	9.792128	10.207872	13
48	9.709306	9.933973	9.775333	10.224667	9.721774	9.929364	9.792410	10.207590	12
49	9.709518	9.933898	9.775621	10.224379	9.721978	9.929286	9.792692	10.207308	11
50	9.709730	9.933822	9.775908	10.224092	9.722181	9.929207	9.792974	10.207026	10
51	9.709941	9.933747	9.776195	10.223805	9.722385	9.929129	9.793256	10.206744	9
52	9.710153	9.933671	9.776482	10.223518	9.722588	9.929050	9.793538	10.206462	8
53	9.710364	9.933596	9.776768	10.223232	9.722791	9.928972	9.793819	10.206181	7
54	9.710575	9.933520	9.777055	10.222945	9.722994	9.928893	9.794101	10.205899	6
55	9.710786	9.933445	9.777342	10.222658	9.723197	9.928814	9.794383	10.205617	5
56	9.710997	9.933369	9.777628	10.222372	9.723400	9.928736	9.794664	10.205336	4
57	9.711208	9.933293	9.777915	10.222085	9.723603	9.928657	9.794946	10.205054	3
58	9.711419	9.933217	9.778201	10.221799	9.723805	9.928578	9.795227	10.204773	2
59	9.711629	9.933141	9.778488	10.221512	9.724007	9.928499	9.795508	10.204492	1
60	9.711839	9.933066	9.778774	10.221226	9.724210	9.928420	9.795789	10.204211	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine.*	Sine	*Co-tang.*	Tangent	M
	Degree 59.				Degree 58.				

Degree 32.				
M	Sine	Co-sine	Tangent	Co-tang.
0	9.724210	9.928420	9.795789	10.204211
1	9.724412	9.928342	9.796070	10.203930
2	9.724614	9.928263	9.796351	10.203649
3	9.724816	9.928183	9.796632	10.203368
4	9.725017	9.928104	9.796913	10.203087
5	9.725219	9.928025	9.897194	10.202806
6	9.725420	9.927946	9.797474	10.202526
7	9.725622	9.927867	9.797755	10.202245
8	9.725823	9.927787	9.798036	10.201964
9	9.726024	9.927708	9.798316	10.201684
10	9.726225	9.927629	9.798596	10.201404
11	9.726426	9.927549	9.798877	10.201123
12	9.726626	9.927470	9.799157	10.200843
13	9.726827	9.927390	9.799437	10.200563
14	9.727027	9.927310	9.799717	10.200283
15	9.727228	9.927231	9.799997	10.200003
16	9.727428	9.927151	9.800277	10.199723
17	9.727628	9.927071	9.800557	10.199443
18	9.727828	9.926991	9.800836	10.199164
19	9.728027	9.926911	9.801116	10.198884
20	9.728227	9.926831	9.801396	10.198604
21	9.728427	9.926751	9.801675	10.198325
22	9.728626	9.926671	9.801955	10.198045
23	9.728825	9.926591	9.802234	10.197766
24	9.729024	9.926511	9.802513	10.197487
25	9.729223	9.926431	9.802792	10.197208
26	9.729422	9.926351	9.803072	10.196928
27	9.729621	9.926270	9.803351	10.196649
28	9.729820	9.926190	9.803630	10.196370
29	9.730018	9.926110	9.803909	10.196091
30	9.730217	9.926029	9.804187	10.195813
31	9.730415	9.925949	9.804466	10.195534
32	9.730613	9.925868	9.804745	10.195255
33	9.730811	9.925788	9.805023	10.194977
34	9.731009	9.925707	9.805302	10.194698
35	9.731206	9.925626	9.805580	10.194420
36	9.731404	9.925545	9.805859	10.194141
37	9.731602	9.925465	9.806137	10.193863
38	9.731799	9.925384	9.806415	10.193585
39	9.731996	9.925303	9.806693	10.193307
40	9.732193	9.925222	9.806971	10.193029
41	9.732390	9.925141	9.807249	10.192751
42	9.732587	9.925060	9.807527	10.192473
43	9.732784	9.924979	9.807805	10.192195
44	9.732980	9.924897	9.808083	10.191917
45	9.733177	9.924816	9.808361	10.191639
46	9.733373	9.924735	9.808638	10.191362
47	9.733569	9.924654	9.808916	10.191084
48	9.733765	9.924572	9.809193	10.190807
49	9.733961	9.924491	9.809471	10.190529
50	9.734157	9.924409	9.809748	10.190252
51	9.734353	9.924328	9.810025	10.189975
52	9.734549	9.924246	9.810302	10.189698
53	9.734744	9.924164	9.810580	10.189420
54	9.734939	9.924083	9.810857	10.189143
55	9.735134	9.924001	9.811134	10.188866
56	9.735330	9.923919	9.811410	10.188590
57	9.735525	9.923837	9.811687	10.188313
58	9.735719	9.923755	9.811964	10.188036
59	9.735914	9.923673	9.812241	10.187759
60	9.736109	9.923591	9.812517	10.187483
	Co-sine	Sine	Co-tang.	Tangent
Degree 57.				

Degree 33.				
Sine	Co-sine	Tangent	Co-tang.	
9.736109	9.923591	9.812517	10.187483	60
9.736303	9.923509	9.812794	10.187206	59
9.736498	9.923427	9.813070	10.186930	58
9.736692	9.923345	9.813347	10.186653	57
9.736886	9.923263	9.813623	10.186377	56
9.737080	9.923181	9.813899	10.186101	55
9.737274	9.923098	9.814176	10.185824	54
9.737467	9.923016	9.814452	10.185548	53
9.737661	9.922933	9.814728	10.185272	52
9.737855	9.922851	9.815004	10.184996	51
9.738048	9.922768	9.815280	10.184720	50
9.738241	9.922686	9.815555	10.184445	49
9.738434	9.922603	9.815831	10.184169	48
9.738627	9.922520	9.816107	10.183893	47
9.738820	9.922438	9.816382	10.183618	46
9.739013	9.922355	9.816658	10.183342	45
9.739206	9.922272	9.816933	10.183067	44
9.739398	9.922189	9.817209	10.182791	43
9.739590	9.922106	9.817484	10.182516	42
9.739783	9.922023	9.817759	10.182241	41
9.739975	9.921940	9.818035	10.181965	40
9.740167	9.921857	9.818310	10.181690	39
9.740359	9.921774	9.818585	10.181415	38
9.740550	9.921691	9.818860	10.181140	37
9.740742	9.921607	9.819135	10.180865	36
9.740934	9.921524	9.819410	10.180590	35
9.741125	9.921441	9.819684	10.180316	34
9.741316	9.921357	9.819959	10.180041	33
9.741508	9.921274	9.820234	10.179766	32
9.741699	9.921190	9.820508	10.179492	31
9.741889	9.921107	9.820783	10.179217	30
9.742080	9.921023	9.821057	10.178943	29
9.742271	9.920939	9.821332	10.178668	28
9.742462	9.920856	9.821606	10.178394	27
9.742652	9.920772	9.821880	10.178120	26
9.742842	9.920688	9.822154	10.177846	25
9.743033	9.920604	9.822429	10.177571	24
9.743223	9.920520	9.822703	10.177297	23
9.743413	9.920436	9.822977	10.177023	22
9.743602	9.920352	9.823251	10.176739	21
9.743792	9.920268	9.823524	10.176476	20
9.743982	9.920184	9.823798	10.176202	19
9.744171	9.920099	9.824072	10.175928	18
9.744361	9.920015	9.824345	10.175655	17
9.744550	9.919931	9.824619	10.175381	16
9.744739	9.919846	9.824893	10.175107	15
9.744928	9.919762	9.825166	10.174834	14
9.745117	9.919677	9.825439	10.174561	13
9.745306	9.919593	9.825713	10.174287	12
9.745494	9.919508	9.825986	10.174014	11
9.745683	9.919424	9.826259	10.173741	10
9.745871	9.919339	9.826532	10.173468	9
9.746060	9.919254	9.826805	10.173195	8
9.746248	9.919169	9.827078	10.172922	7
9.746436	9.919085	9.827351	10.172649	6
9.746624	9.919000	9.827624	10.172376	5
9.746812	9.918915	9.827897	10.172103	4
9.746999	9.918830	9.828170	10.171830	3
9.747187	9.918745	9.828442	10.171558	2
9.747374	9.918659	9.828715	10.171285	1
9.747562	9.918574	9.828987	10.171013	0
Co-sine	Sine	Co-tang.	Tangent	M
Degree 56.				

	Degree 34.				Degree 35.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.747562	9.918574	9.828987	10.171013	9.758591	9.913365	9.845227	10.154773	60
1	9.747749	9.918489	9.829260	10.170740	9.758772	9.913276	9.845496	10.154504	59
2	9.747936	9.918404	9.829532	10.170468	9.758952	9.913187	9.845764	10.154236	58
3	9.748123	9.918318	9.829805	10.170195	9.759132	9.913099	9.846033	10.153967	57
4	9.748310	9.918233	9.830077	10.169923	9.759312	9.913010	9.846302	10.153698	56
5	9.748497	9.918147	9.830349	10.169651	9.759492	9.912922	9.846570	10.153430	55
6	9.748683	9.918062	9.830621	10.169379	9.759672	9.912833	9.846839	10.153161	54
7	9.748870	9.917976	9.830893	10.169107	9.759852	9.912744	9.847108	10.152892	53
8	9.749056	9.917891	9.831165	10.168835	9.760031	9.912655	9.847376	10.152624	52
9	9.749242	9.917805	9.831437	10.168563	9.760211	9.912566	9.847644	10.152356	51
10	9.749429	9.917719	9.831709	10.168291	9.760390	9.912477	9.947913	10.152087	50
11	9.749615	9.917634	9.831981	10.168019	9.760569	9.912388	9.848181	10.151819	49
12	9.749801	9.917548	9.832253	10.167747	9.760748	9.912299	9.848449	10.151551	48
13	9.749987	9.917462	9.832525	10.167475	9.760927	9.912210	9.848717	10.151283	47
14	9.750172	9.917376	9.832796	10.167204	9.761106	9.912121	9.848988	10.151014	46
15	9.750358	9.917290	9.833068	10.166932	9.761285	9.912031	9.849254	10.150746	45
16	9.750543	9.917204	9.833339	10.166661	9.761464	9.911942	9.849522	10.150478	44
17	9.750729	9.917118	9.833611	10.166389	9.761642	9.911853	9.849790	10.150210	43
18	9.750914	9.917032	9.833882	10.166118	9.761821	9.911763	9.850057	10.149943	42
19	9.751099	9.916946	9.834154	10.165846	9.761999	9.911674	9.850325	10.149675	41
20	9.751284	9.916859	9.834425	10.165575	9.762177	9.911584	9.850593	10.149407	40
21	9.751469	9.916773	9.834696	10.165304	9.762356	9.911495	9.850861	10.149139	39
22	9.751654	9.916687	9.834967	10.165033	9.762534	9.911405	9.851129	10.148871	38
23	9.751839	9.916600	9.835238	10.164762	9.762712	9.911315	9.851396	10.148604	37
24	9.752023	9.916514	9.835509	10.164491	9.762889	9.911226	9.851664	10.148336	36
25	9.752207	9.916427	9.835780	10.164220	9.763067	9.911136	9.851931	10.148069	35
26	9.752392	9.916341	9.836051	10.163949	9.763245	9.911046	9.852199	10.147801	34
27	9.752576	9.916254	9.836322	10.163678	9.763422	9.910956	9,852466	10.147534	33
28	9.752760	9.916167	9.836593	10.163407	9.763600	9.910866	9.852733	10.147267	32
29	9.752944	9.916081	9.836864	10.163136	9.763777	9.910776	9.853001	10.146999	31
30	9.753128	9.915994	9.837134	10.162866	9.763954	9.910686	9.853268	10.146732	30
31	9.753312	9.915907	9.837405	10.162595	9.765131	9.910596	9.853532	10.146465	29
32	9.753495	9.915820	9.837675	10.162325	9.764308	9.910506	9.853802	10.146198	28
33	9.753679	9.915733	9.837946	10.162054	9.764485	9.910415	9.854069	10.145931	27
34	9.753862	9.915646	9.838216	10.161784	9.764662	9.910325	9.854336	10.145664	26
35	9.754046	9.915559	9.838487	10.161513	9.764838	9.910235	9.854603	10.145397	25
36	9.754229	9.915472	9.838757	10.161243	9.765015	9.910144	9.854870	10.145130	24
37	9.754412	9.915385	9.839027	10.160973	9.765191	9.910054	9.855137	10.144863	23
38	9.754595	9.915297	9.839297	10.160703	9.765367	9.900963	9.855404	10.144596	22
39	9.754778	9.915210	9.839568	10.160432	9.765544	9.909873	9.855671	10.144329	21
40	9.754960	9.915123	9.839838	10.160162	9.765720	9.909782	9.855938	10.144062	20
41	9.755143	9.915035	9.840108	10.159892	9.765896	9.909691	9.856204	10.143796	19
42	9.755326	9.914948	9.840378	10.159622	9.766072	9.909601	9.856471	10.143529	18
43	9.755508	9.914860	9.840648	10.159352	9.766247	9.909510	9.856737	10.143263	17
44	9.755690	9.914773	9.840917	10.159083	9.766423	9.909419	9.857004	10.142996	16
45	9.755872	9.914685	9.841187	10.158813	9.766598	9.909328	9.857270	10.142730	15
46	9.756054	9.914598	9.841457	10.158543	9.766774	9.909237	9.857537	10.142463	14
47	9.756236	9.914510	9.841727	10.158273	9.766949	9.909146	9.857803	10.142197	13
48	9.756418	9.914422	9.841996	10.158004	9.767124	9.909055	9.858069	10.141931	12
49	9.756600	9.914334	9.842266	10.157734	9.767300	9.908964	9.858336	10.141664	11
50	9.756782	9.914246	9.842535	10.157465	9.767475	9.908873	9.858602	10.141398	10
51	9.756963	9.914158	9.842805	10.157195	9.767649	9.908781	9.858868	10.141132	9
52	9.757144	9.914070	9.843074	10.156926	9.767824	9.908690	9.859134	10.140866	8
53	9.757326	9.913982	9.843343	10.156657	9.767999	9.908599	9.859400	10.140600	7
54	9.757507	9.913894	9.843612	10.156388	9.768173	9.908507	9.859666	10.140334	6
55	9.757688	9.913806	9.843882	10.156118	9.768348	9.908416	9.859932	10.140068	5
56	9.757869	9.913718	9.844151	10.155849	9.768522	9.908324	9.860108	10.139802	4
57	9.758059	9.913630	9.844420	10.155580	9.768697	9.908233	9.860464	10.139536	3
58	9.758230	9.913541	9.844689	10.155311	9.768871	9.908141	9.860730	10.139270	2
59	9.758411	9.913453	9.844958	10.155042	9.769045	9.908049	9.860995	10.139005	1
60	9.758591	9.913365	9.845227	10.154773	9.769219	9.907958	9.861261	10.138739	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine.*	Sine	*Co-tang.*	Tangent	M
	Degree 55.				Degree 54.				

	Degree 36.				Degree 37.				
M	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.769219	9.907958	9.861261	10.138739	9.779463	9.902349	9.877114	10.122886	60
1	9.769393	9.907866	9.861527	10.138473	9.779631	9.902253	9.877377	10.122623	59
2	9.769566	9.907774	9.861792	10.138208	9.779798	9.902158	9.877640	10.122360	58
3	9.769740	9.907682	9.862058	10.137942	9.779966	9.902063	9.877903	10.122097	57
4	9.769913	9.907590	9.862323	10.137677	9.780133	9.901967	9.878165	10.121835	56
5	9.770087	9.907498	9.862589	10.137411	9.780300	9.901872	9.878428	10.121572	55
6	9.770260	9.907406	9.862854	10.137146	9.780467	9.901776	9.878691	10.121309	54
7	9.770433	9.907314	9.863119	10.136881	9.780634	9.901681	9.878953	10.121047	53
8	9.770606	9.907222	9.863385	10.136615	9.780801	9.901585	9.879216	10.120784	52
9	9.770779	9.907129	9.863650	10.136350	9.780968	9.901490	9.879478	10.120522	51
10	9.770952	9.907037	9.863915	10.136085	9.781134	9.901394	9.879741	10.120259	50
11	9.771125	9.906945	9.864180	10.135820	9.781301	9.901298	9.880003	10.119997	49
12	9.771298	9.906852	9.864445	10.135555	9.781468	9.901202	9.880265	10.119735	48
13	9.771470	9.906760	9.864710	10.135290	9.781634	9.901106	9.880528	10.119472	47
14	9.771643	9.906667	9.864975	10.135025	9.781800	9.901010	9.880790	10.119210	46
15	9.771815	9.906575	9.865240	10.134760	9.781966	9.900914	9.881052	10.118948	45
16	9.771987	9.906482	9.865505	10.134495	9.782132	9.900828	9.881314	10.118686	44
17	9.772159	9.906389	9.865770	10.134230	9.782298	9.900722	9.881577	10.118423	43
18	9.772331	9.906296	9.866035	10.133965	9.782464	9.900626	9.881839	10.118161	42
19	9.772503	9.906204	9.866300	10.133700	9.782630	9.900529	9.882101	10.117899	41
20	9.772675	9.906111	9.866564	10.133436	9.782796	9.900433	9.882363	10.117637	40
21	9.772847	9.906018	9.866829	10.133171	9.782961	9.900337	9.882625	10.117375	39
22	9.773018	9.905925	9.867094	10.132906	9.783127	9.900240	9.882887	10.117113	38
23	9.773190	9.905832	9.867358	10.132642	9.783292	9.900144	9.883148	10.116852	37
24	9.773361	9.905739	9.867623	10.132377	9.783458	9.900047	9.883410	10.116590	36
25	9.773533	9.905645	9.867887	10.132133	9.783623	9.899951	9.883672	10.116328	35
26	9.773704	9.905552	9.868152	10.131848	9.783788	9.899854	9.883934	10.116066	34
27	9.773875	9.905459	9.868416	10.131584	9.783953	9.899757	9.884196	10.115804	33
28	9.774046	9.905366	9.868680	10.131320	9.784118	9.899660	9.884457	10.115543	32
29	9.774217	9.905272	9.868945	10.131055	9.784282	9.899564	9.884719	10.115281	31
30	9.774388	9.905179	9.869209	10.130791	9.784447	9.899467	9.884980	10.115020	30
31	9.774558	9.905085	9.869473	10.130527	9.784616	9.899370	9.885242	10.114758	29
32	9.774729	9.904992	9.869737	10.130263	9.784776	9.899273	9.885504	10.114496	28
33	9.774899	9.904898	9.870001	10.129999	9.784941	9.899176	9.885765	10.114235	27
34	9.775070	9.904804	9.870265	10.129735	9.785105	9.899078	9.886026	10.113974	26
35	9.775240	9.904711	9.870529	10.129471	9.785269	9.898981	9.886288	10.113712	25
36	9.775410	9.904617	9.870793	10.129207	9.785433	9.898884	9.886549	10.113451	24
37	9.775580	9.904523	9.871057	10.128943	9.785597	9.898787	9.886811	10.113189	23
38	9.775750	9.904429	9.871321	10.128679	9.785761	9.898689	9.887072	10.112928	22
39	9.775920	9.904335	9.871585	10.128415	9.785925	9.898592	9.887333	10.112667	21
40	9.776090	9.904241	9.871849	10.128151	9.786089	9.898494	9.887594	10.112406	20
41	9.776259	9.904147	9.872112	10.127888	9.786252	9.898397	9.887855	10.112145	19
42	9.776429	9.904053	9.872376	10.127624	9.786416	9.898299	9.888116	10.111884	18
43	9.776598	9.903959	9.872640	10.127360	9.786579	9.898202	9.888378	10.111622	17
44	9.776768	9.903864	9.872903	10.127097	9.786742	9.898104	9.888639	10.111361	16
45	9.776937	9.903770	9.873167	10.126833	9.786906	9.898006	9.888900	10.111100	15
46	9.777106	9.903676	9.873430	10.126570	9.787069	9.897908	9.889161	10.110839	14
47	9.777275	9.903581	9.873694	10.126306	9.787232	9.897810	9.889421	10.110579	13
48	9.777444	9.903487	9.873957	10.126043	9.787395	9.897712	9.889682	10.110318	12
49	9.777613	9.903392	9.874220	10.125780	9.787557	9.897614	9.889943	10.110057	11
50	9.777781	9.903298	9.874484	10.125516	9.787720	9.897516	9.890204	10.109796	10
51	9.777950	9.903203	9.874747	10.125253	9.787883	9.897418	9.890465	10.109535	9
52	9.778119	9.903108	9.875010	10.124990	9.788045	9.897320	9.890725	10.109275	8
53	9.778287	9.903014	9.875273	10.124727	9.788208	9.897222	9.890986	10.109014	7
54	9.778455	9.902919	9.875537	10.124463	9.788370	9.897123	9.891247	10.108753	6
55	9.778624	9.902824	9.875800	10.124200	9.788532	9.897025	9.891507	10.108493	5
56	9.778792	9.902729	9.876063	10.123937	9.788694	9.896926	9.891768	10.108232	4
57	9.778960	9.902634	9.876326	10.123674	9.788856	9.896828	9.892028	10.107972	3
58	9.779128	9.902539	9.876589	10.123411	9.789018	9.896729	9.892289	10.107711	2
59	9.779295	9.902444	9.876852	10.123148	9.789180	9.896631	9.892549	10.107451	1
60	9.779463	9.902349	9.877114	10.122886	9.789342	9.896532	9.892810	10.107190	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang	Tangent	M
	Degree 53.				Degree 52.				

Degree 38.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*
0	9.789342	9.896532	9.892810	10.107190
1	9.789504	9.896433	9.893070	10.106930
2	9.789665	9.896335	9.893331	10.106669
3	9.789827	9.896236	9.893591	10.106409
4	9.789988	9.896137	9.893851	10.106149
5	9.790149	9.896038	9.894111	10.105889
6	9.790310	9.895939	9.894372	10.105628
7	9.790471	9.895840	9.894632	10.105368
8	9.790632	9.895741	9.894892	10.105108
9	9.790793	9.895641	9.895152	10.104848
10	9.790954	9.895542	9.895412	10.104588
11	9.791115	9.895443	9.895672	10.104328
12	9.791275	9.895343	9.895932	10.104068
13	9.791436	9.895244	9.896192	10.103808
14	9.791596	9.895144	9.896452	10.103548
15	9.791756	9.895045	9.896712	10.103288
16	9.791917	9.894945	9.896971	10.103029
17	9.792077	9.894846	9.897231	10.102769
18	9.792237	9.894746	9.897491	10.102509
19	9.792397	9.894646	9.897751	10.102249
20	9.792557	9.894546	9.898010	10.101990
21	9.792716	9.894445	9.898270	10.101730
22	9.792876	9.894346	9.898530	10.101470
23	9.793035	9.894246	9.898789	10.101211
24	9.793195	9.894146	9.899049	10.100951
25	9.793354	9.894046	9.899308	10.100692
26	9.793514	9.893946	9.899568	10.100432
27	9.793673	9.893846	9.899827	10.100173
28	9.793832	9.893745	9.900087	10.099913
29	9.793991	9.893645	9.900346	10.099654
30	9.794150	9.893544	9.900605	10.099395
31	9.794308	9.893444	9.900864	10.099136
32	9.794467	9.893343	9.901124	10.098876
33	9.794626	9.893243	9.901383	10.098617
34	9.794784	9.893142	9.901642	10.098358
35	9.794942	9.893041	9.901901	10.098099
36	9.795101	9.892940	9.902160	10.097840
37	9.795259	9.892839	9.902420	10.097580
38	9.795417	9.892738	9.902679	10.097321
39	9.795575	9.892638	9.902938	10.097062
40	9.795733	9.892536	9.903197	10.096803
41	9.795891	9.892435	9.903456	10.096544
42	9.796049	9.892334	9.903714	10.096286
43	9.796206	9.892233	9.903973	10.096027
44	9.796364	9.892132	9.904232	10.095768
45	9.796521	9.892030	9.904491	10.095509
46	9.796678	9.891929	9.904750	10.095250
47	9.796836	9.891827	9.905008	10.094992
48	9.796993	9.891726	9.905267	10.094733
49	9.797150	9.891624	9.905526	10.094474
50	9.797307	9.891522	9.905785	10.094215
51	9.797464	9.891421	9.906043	10.093957
52	9.797621	9.891319	9.906302	10.093698
53	9.797777	9.891217	9.906560	10.093440
54	9.797934	9.891115	9.906819	10.093181
55	9.798091	9.891013	9.907077	10.092923
56	9.798247	9.890911	9.907336	10.092664
57	9.798403	9.890809	9.907594	10.092406
58	9.798560	9.890707	9'907853	10.092147
59	9.798716	9.890605	9.908111	10.091889
60	9.798872	9.890503	9.908369	10.091631
	Co-sine	Sine	*Co-tang.*	Tangent
Degree 51.				

Degree 39.				
Sine	*Co-sine*	Tangent	*Co-tang.*	
9.798872	9.890503	9.908369	10.091631	60
9.799028	9.890400	9.908628	10.091372	59
9.799184	9.890298	9.908886	10.091114	58
9.799339	9.890195	9.909144	10.090856	57
9.799495	9.890093	9.909402	10.090598	56
9.799651	9.889990	9.909660	10.090340	55
9.799806	9.889888	9.909918	10.090082	54
9.799962	9.889785	9.910177	10.089823	53
9.800117	9.889682	9.910435	10.089565	52
9.800272	9.889579	9.910693	10.089307	51
9.800427	9.889477	9.910951	10.089049	50
9.890582	9.889374	9.911209	10.088791	49
9.890737	9.889271	9.911467	10.088533	48
9.800892	9.889168	9.911725	10.088275	47
9.801047	9.889064	9.911982	10.088018	46
9.801201	9.888961	9.912240	10.087760	45
9.801356	9.888858	9.912498	10.087502	44
9.801511	9.888755	9.912756	10.087244	43
9.801665	9.888651	9.913014	10.086986	42
9.801819	9.888548	9.913271	10.086729	41
9.801973	9.888444	9.913529	10.086471	40
9.802128	9.888341	9.913787	10.086213	39
9.802282	9.888237	9.914044	10.085956	38
9.802436	9.888134	9.914302	10.085698	37
9.802589	9.888030	9.914560	10.085440	36
9.802743	9.887926	9.914817	10.085183	35
9.802897	9.887822	9.915075	10.084925	34
9.803050	9.887718	9.915332	10.084668	33
9.803204	9.887614	9.915590	10.084410	32
9.803357	9.887510	9.915847	10.084153	31
9.803511	9.887406	9.916104	10.083895	30
9.803664	9.887302	9.916362	10.083638	29
9.803817	9.887198	9.916619	10.083381	28
9.803970	9.887093	9.916877	10.083123	27
9.804123	9.886989	9.917134	10.082866	26
9.804276	9.886885	9.917391	10.082609	25
9.804428	9.886780	9.917648	10.082352	24
9.804581	9.886676	9.917906	10.082094	23
9.804734	9.886571	9.918163	10.081837	22
9.804886	9.886466	9.918420	10.081580	21
9.805039	9.886362	9.918677	10.081323	20
9.805191	9.886257	9.918934	10.081066	19
9.805343	9.886152	9.919191	10.080809	18
9.805495	9.886047	9.919448	10.080552	17
9.805647	9.885942	9.919705	10.080295	16
9.805799	9.885837	9.919962	10.080038	15
9.805951	9.885732	9.920219	10.079781	14
9.806103	9.885627	9.920476	10.079524	13
9.806254	9.885522	9.920733	10.079267	12
9.806406	9.885416	9.920990	10.079010	11
9.806557	9.885311	9.921247	10.078753	10
9.806709	9.885205	9.921503	10.078497	9
9.306860	9.885100	9.921760	10.078240	8
9.807011	9.884994	9.922017	10.077983	7
9.807163	9.884889	9.922274	10.077726	6
9.807314	9.884783	9.922530	10.077470	5
9.807465	9.884677	9.922787	10.077213	4
9.807615	9.884572	9.923044	10.076956	3
9.807766	9.884466	9.923300	10.076700	2
9.807917	9.884360	9.923557	10.076443	1
9.808067	9.884254	9.923814	10.076186	0
Co-sine.	Sine	*Co-tang.*	Tangent	M
Degree 50.				

A Table of Artificial Sines and Tangents.

	Degree 40.				Degree 41.				
M	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.808067	9.884254	9.923814	10.076186	9.816943	9.877780	9.939163	10.060837	60
1	9.808218	9.884148	9.924070	10.075930	9.817088	9.877670	9.939418	10.060582	59
2	9.808368	9.884042	9.924327	10.075673	9.817233	9.877560	9.939673	10.060327	58
3	9.808519	9.883936	9.924583	10.075417	9.817379	9.877450	9.939928	10.060072	57
4	9.808669	9.883829	9.924840	10.075160	9.817524	9.877340	9.940183	10.059817	56
5	9.808819	9.883723	9.925096	10.074904	9.817668	9.877230	9.940439	10.059561	55
6	9.808969	9.883617	9.925352	10.074648	9.817813	9.877120	9.940694	10.059306	54
7	9.809119	9.883510	9.925609	10.074391	9.817958	9.877010	9.940949	10.059051	53
8	9.809269	9.883404	9.925865	10.074135	9.818103	9.876899	9.941204	10.058796	52
9	9.809419	9.883297	9.926122	10.073878	9.818247	9.876789	9.941459	10.058541	51
10	9.809569	9.883191	9.926378	10.073622	9.818392	9.876678	9.941713	10.058287	50
11	9.809718	9.883084	9.926634	10.073366	9.818536	9.876568	9.941968	10.058032	49
12	9.809868	9.882977	9.926890	10.073110	9.818681	9.876457	9.942223	10.057777	48
13	9.810017	9.882871	9.927147	10.072853	9.818825	9.876347	9.942478	10.057522	47
14	9.810167	9.882764	9.927403	10.072597	9.818969	9.876236	9.942733	10.057267	46
15	9.810316	9.882657	9.927659	10.072341	9.819113	9.876125	9.942988	10.057012	45
16	9.810465	9.882550	9.927915	10.072085	9.819257	9.876014	9.943243	10.056757	44
17	9.810614	9.882443	9.928171	10.071829	9.819401	9.875904	9.943498	10.056502	43
18	9.810763	9.882336	9.928427	10.071573	9.819545	9.875793	9.943752	10.056248	42
19	9.810912	9.882229	9.928684	10.071316	9.819689	9.875682	9.944007	10.055993	41
20	9.811061	9.882121	9.928940	10.071060	9.819832	9.875571	9.944262	10.055738	40
21	9.811210	9.882014	9.929196	10.070804	9.819976	9.875459	9.944517	10.055483	39
22	9.811358	9.881907	9.929452	10.070548	9.820120	9.875348	9.944771	10.055229	38
23	9.811507	9.881799	9.929708	10.070292	9.820263	9.875237	9.945026	10.054974	37
24	9.811655	9.881692	9.929964	10.070036	9.820406	9.875126	9.945281	10.054719	36
25	9.811804	9.881584	9.930220	10.069781	9.820549	9.875014	9.945535	10.054464	35
26	9.811952	9.881477	9.930475	10.069525	9.820693	9.874903	9.945790	10.054210	34
27	9.812100	9.881369	9.930731	10.069269	9.820836	9.874791	9.946045	10.053955	33
28	9.812248	9.881261	9.930987	10.069013	9.820979	9.874680	9.946299	10.053701	32
29	9.812396	9.881153	9.931243	10.068757	9.821122	9.874568	9.946554	10.053446	31
30	9.812544	9.881046	9.931499	10.068501	9.821265	9.874456	9.946808	10.053192	30
31	9.812692	9.880938	9.931755	10.068245	9.821407	9.874344	9.947063	10.052937	29
32	9.812840	9.880830	9.932010	10.067990	9.821550	9.874232	9.947318	10.052682	28
33	9.812988	9.880722	9.932266	10.067734	9.821693	9.874121	9.947572	10.052428	27
34	9.813135	9.880613	9.932522	10.067478	9.821835	9.874009	9.947827	10.052173	26
35	9.813283	9.880505	9.932778	10.067222	9.821977	9.873896	9.948081	10.051919	25
36	9.813430	9.880397	9.933033	10.066967	9.822120	9.873784	9.948335	10.051665	24
37	9.813578	9.880289	9.933289	10.066711	9.822262	9.873672	9.948590	10.051410	23
38	9.813725	9.880180	9.933545	10.066455	9.822404	9.873560	9.948844	10.051156	22
39	9.813872	9.880072	9.933800	10.066200	9.822546	9.873448	9.949099	10.050901	21
40	9.814019	9.879963	9.934056	10.065944	9.822688	9.873335	9.949353	10.050647	20
41	9.814166	9.879855	9.934311	10.065689	9.822830	9.873223	9.949608	10.050392	19
42	9.814313	9.879746	9.934567	10.065433	9.822972	9.873110	9.949862	10.050138	18
43	9.814460	9.879637	9.934822	10.065178	9.823114	9.872998	9.950116	10.049884	17
44	9.814607	9.879529	9.935078	10.064922	9.823255	9.872885	9.950370	10.049630	16
45	9.814753	9.879420	9.935333	10.064667	9.823397	9.872772	9.950625	10.049375	15
46	9.814900	9.879311	9.935589	10.064411	9.823538	9.872659	9.950879	10.049121	14
47	9.815046	9.879202	9.935844	10.064156	9.823680	9.872546	9.951133	10.048867	13
48	9.815193	9.879093	9.936100	10.063900	9.823821	9.872434	9.951388	10.048612	12
49	9.815339	9.878984	9.936355	10.063645	9.823963	9.872321	9.951642	10.048358	11
50	9.815485	9.878875	9.936610	10.063389	9.824104	9.872208	9.951896	10.048104	10
51	9.815632	9.878766	9.936866	10.063134	9.824245	9.872095	9.952150	10.047850	9
52	9.815778	9.878656	9.937121	10.062879	9.824386	9.871981	9.952405	10.047595	8
53	9.815924	9.878547	9.937377	10.062623	9.824527	9.871868	9.952659	10.047341	7
54	9.816069	9.878438	9.937632	10.062368	9.824668	9.871755	9.952913	10.047087	6
55	9.816215	9.878328	9.937887	10.062113	9.824808	9.871641	9.953167	10.046833	5
56	9.816361	9.878219	9.938142	10.061858	9.824949	9.871528	9.953421	10.046579	4
57	9.816507	9.878109	9.938398	10.061602	9.825090	9.871414	9.953675	10.046325	3
58	9.816652	9.877999	9.938653	10.061347	9.825230	9.871301	9.953929	10.046071	2
59	9.816798	9.877890	9.938908	10.061092	9.825371	9.871187	9.954183	10.045817	1
60	9.816943	9.877780	9.939163	10.060837	9.825511	9.871073	9.954437	10.045563	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang	Tangent	M
	Degree 49.				Degree 48.				

A Table of Artificial Sines and Tangents.

	Degree 42.				Degree 43.				
M	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.825511	9.871073	9.954437	10.045563	9.833783	9.864127	9.969656	10.030344	60
1	9.825651	9.870960	9.954691	10.045309	9.833919	9.864010	9.969909	10.030091	59
2	9.825791	9.870846	9.954946	10.045054	9.834054	9.863892	9.970162	10.029838	58
3	9.825931	9.870732	9.955200	10.044800	9.834189	9.863774	9.970416	10.029584	57
4	9.826071	9.870618	9.955454	10.044546	9.834325	9.863656	9.970669	10.029331	56
5	9.826211	9.870504	9.955708	10.044292	9.834460	9.863538	9.970922	10.029078	55
6	9.826351	9.870390	9.955961	10.044039	9.835594	9.863419	9.971175	10.028827	54
7	9.826491	9.870276	9.956216	10.043785	9.834730	9.863301	9.971429	10.028571	53
8	9.826631	9.870161	9.956469	10.043531	9.834865	9.863183	9.971682	10.028318	52
9	9.826770	9.870047	9.956723	10.043277	9.834999	9.863064	9.971935	10.028065	51
10	9.826910	9.869933	9.956977	10.043023	9.835134	9.862946	9.972188	10.027812	50
11	9.827049	9.869818	9.957231	10.042769	9.835269	9.862827	9.972441	10.027559	49
12	9.827189	9.869704	9.957485	10.042515	9.835403	9.862709	9.972694	10.027305	48
13	9.827328	9.869589	9.957739	10.042261	9.835538	9.862590	9.972948	10.027052	47
14	9.827467	9.869474	9.957993	10.042007	9.835672	9.862471	9.973201	10.026799	46
15	9.827606	9.869360	9.958247	10.041753	9.835807	9.862353	9.973454	10.026546	45
16	9.827745	9.869245	9.958500	10.041500	9.835941	9.862234	9.973707	10.026293	44
17	9.827884	9.869130	9.958754	10.041246	9.836075	9.862115	9.973960	10.026040	43
18	9.828023	9.869015	9.959008	10.040992	9.836209	9.861996	9.974213	10.025787	42
19	9.828162	9.868900	9.959262	10.040738	9.836343	9.861877	9.974466	10.025534	41
20	9.828301	9.868785	9.959516	10.040484	9.836477	9.861758	9.974720	10.025280	40
21	9.828439	9.868670	9.959769	10.040231	9.836611	9.861638	9.974973	10.025027	39
22	9.828578	9.868555	9.960023	10.039977	9.836745	9.861519	9.975226	10.024774	38
23	9.828716	9.868440	9.960277	10.039723	9.836878	9.861400	9.975479	10.024521	37
24	9.828855	9.868324	9.960530	10.039470	9.837012	9.861280	9.975732	10.024268	36
25	9.828993	9.868209	9.960784	10.039216	9.837146	9.861161	9.975985	10.024015	35
26	9.829131	9.868093	9.961038	10.038962	9.837279	9.861041	9.976238	10.023762	34
27	9.829269	9.867978	9.961292	10.038708	9.837412	9.860922	9.976491	10.023509	33
28	9.829407	9.867862	9.961545	10.038455	9.837546	9.860802	9.976744	10.023256	32
29	9.829545	9.867747	9.961799	10.038201	9.837679	9.860682	9.976997	10.023003	31
30	9.829683	9.867631	9.962052	10.037948	9.837812	9.860562	9.977250	10.022750	30
31	9.829821	9.867515	9.962306	10.037694	9.837945	9.860442	9.977503	10.022497	29
32	9.829959	9.867399	9.962560	10.037440	9.838078	9.860322	9.977756	10.022244	28
33	9.830097	9.867283	9.962813	10.037187	9.838211	9.860202	9.978009	10.021991	27
34	9.830234	9.867167	9.963067	10.036933	9.838344	9.860082	9.978262	10.021738	26
35	9.830372	9.867051	9.963320	10.036680	9.838477	9.859962	9.978515	10.021485	25
36	9.830509	9.866935	9.963574	10.036426	9.838610	9.859842	9.978768	10.021232	24
37	9.830646	9.866819	9.963828	10.036172	9.838742	9.859721	9.979021	10.020979	23
38	9.830784	9.866703	9.964081	10.035919	9.838875	9.859601	9.979274	10.020726	22
39	9.830921	9.866586	9.964335	10.035665	9.839007	9.859480	9.979527	10.020473	21
40	9.831058	9.866470	9.964588	10.035412	9.839140	9.859360	9.979780	10.020220	20
41	9.831195	9.866353	9.964842	10.035158	9.839272	9.859239	9.980033	10.019967	19
42	9.831332	9.866237	9.965095	10.034905	9.839480	9.859119	9.980286	10.019714	18
43	9.831469	9.866120	9.965349	10.034651	9.839536	9.858998	9.980538	10.019462	17
44	9.831606	9.866004	9.965602	10.034398	9.839668	9.858877	9.980791	10.019209	16
45	9.831742	9.865887	9.965855	10.034145	9.839800	9.858756	9.981044	10.018956	15
46	9.831879	9.865770	9.966109	10.033891	9.839932	9.858635	9.981297	10.018703	14
47	9.832015	9.865653	9.966362	10.033638	9.840064	9.858514	9.981550	10.018450	13
48	9.832152	9.865536	9.966616	10.033384	9.840196	9.858393	9.981803	10.018197	12
49	9.832288	9.865419	9.966869	10.033131	9.840328	9.858272	9.982056	10.017944	11
50	9.832425	9.865302	9.967123	10.032877	9.840459	9.858151	9.982309	10.017691	10
51	9.832561	9.865185	9.967376	10.032624	9.840591	9.858029	9.982562	10.017438	9
52	9.832697	9.865068	9.967629	10.032371	9.840722	9.857908	9.982814	10.017186	8
53	9.832833	9.864950	9.967883	10.032117	9.840854	9.857786	9.983067	10.016933	7
54	9.832969	9.864833	9.968136	10.031864	9.840985	9.857665	9.983320	10.016680	6
55	9.833105	9.864716	9.968389	10.031611	9.841116	9.857543	9.983573	10.016427	5
56	9.833241	9.864598	9.968643	10.031357	9.841247	9.857422	9.983826	10.016174	4
57	9.833376	9.864481	9.968896	10.031104	9.841378	9.857300	9.984079	10.015921	3
58	9.833512	9.864363	9.969149	10.030851	9.841509	9.857178	9.984332	10.015668	2
59	9.833648	9.864245	9.969403	10.030597	9.841640	9.857056	9.984584	10.015416	1
60	9.833783	9.864127	9.969656	10.030344	9.841771	9.856924	9.984837	10.015163	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine.	Sine	Co-tang.	Tangent	M
	Degree 47.				Degree 46.				

Degree 44.

M	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.841771	9.856934	9.984837	10.015162	60
1	9.841902	9.856812	9.985090	10.014910	59
2	9.842033	9.856690	9.985343	10.014657	58
3	9.842163	9.856568	9.985596	10.014404	57
4	9.842294	9.856446	9.985848	10.014152	56
5	9.842424	9.856323	9.986101	10.013899	55
6	9.842555	9.856201	9.986354	10.013646	54
7	9.842685	9.856078	9.986607	10.013393	53
8	9.842815	9.855956	9.986859	10.013140	52
9	9.842946	9.855833	9.987112	10.012888	51
10	9.843076	9.855711	9.987365	10.012635	50
11	9.843206	9.855588	9.987618	10.012382	49
12	9.843336	9.855465	9.987871	10.012129	48
13	9.843466	9.855342	9.988123	10.011877	47
14	9.843595	9.855219	9.988376	10.011624	46
15	9.843725	9.855096	9.988629	10.011371	45
16	9.843855	9.854973	9.988882	10.011118	44
17	9.843984	9.854850	9.989134	10.010866	43
18	9.844114	9.854727	9.989387	10.010613	42
19	9.844243	9.854603	9.989640	10.010360	41
20	9.844372	9.854480	9.989893	10.010107	40
21	9.844502	9.854356	9.990145	10.009855	39
22	9.844631	9.854233	9.990398	10.009602	38
23	9.844760	9.854109	9.990651	10.009349	37
24	9.844889	9.853986	9.990903	10.009096	36
25	9.845018	9.853862	9.991156	10.008844	35
26	9.845147	9.853738	9.991409	10.008591	34
27	9.845276	9.853614	9.991662	10.008338	33
28	9.845405	9.853490	9.991914	10.008086	32
29	9.845533	9.853366	9.992167	10.007833	31
30	9.845662	9.853242	9.992420	10.007580	30
31	9.845790	9.853118	9.992672	10.007328	29
32	9.845919	9.852994	9.992925	10.007075	28
33	9.846047	9.852869	9.993178	10.006822	27
34	9.846175	9.852745	9.993430	10.006569	26
35	9.846304	9.852620	9.993683	10.006317	25
36	9.846432	9.852496	9.993936	10.006064	24
37	9.846560	9.852371	9.994189	10.005811	23
38	9.846688	9.852247	9.994441	10.005559	22
39	9.846816	9.852122	9.994694	10.005306	21
40	9.846944	9.851997	9.994947	10.005053	20
41	9.847071	9.851872	9.995199	10.004801	19
42	9.847199	9.851747	9.995452	10.004548	18
43	9.847327	9.851622	9.995705	10.004295	17
44	9.847454	9.851497	9.995957	10.004043	16
45	9.847582	9.851372	9.996210	10.003790	15
46	9.847709	9.851246	9.996463	10.003537	14
47	9.847836	9.851121	9.996715	10.003285	13
48	9.847964	9.850996	9.996968	10.003032	12
49	9.848091	9.850870	9.997221	10.002779	11
50	9.848218	9.850745	9.997473	10.002527	10
51	9.848345	9.850619	9.997726	10.002274	9
52	9.848472	9.850493	9.997979	10.002021	8
53	9.848599	9.850368	9.998231	10.001769	7
54	9.848726	9.850242	9.998484	10.001516	6
55	9.848852	9.850116	9.998737	10.001263	5
56	9.848979	9.849990	9.998989	10.001011	4
57	9.849106	9.849864	9.999242	10.001758	3
58	9.849232	9.849738	9.999495	10.000505	2
59	9.849359	9.849611	9.999747	10.000253	1
60	9.849485	9.849485	10.000000	10.000000	0
	Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 45.

CHILIADES
DECEM
LOGARITHMORUM,
OR
The LOGARITHMS of all NUMBERS
From an Unite to 10000: Whereby the Logarithms of all Numbers under 1000000 may be speedily deduced.

First Composed by that Excellent Mathematician

Mr. *HENRY BRIGGS*,
Professor of Geometry in the University of *Oxford*.

And their Use now Amplified,

By Capt. *SAMUEL STURMY*.

N	Log.	N	Log.	N	Log.	N	Log.	N	Log.
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342422	42	1.623249	62	1.792391	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799340	83	1.919078
4	0.602060	24	1.380211	44	1.643452	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653212	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431363	47	1.672097	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944482
9	0.954242	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954242
11	1.041393	31	1.491361	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.631479	54	1.732393	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740362	75	1.875061	95	1.977723
16	1.204120	36	1.556303	56	1.748188	76	1.880813	96	1.982271
17	1,230449	37	1.568202	57	1.755875	77	1.886491	97	1.986771
18	1.255272	38	1.579783	58	1.763428	78	1.892094	98	1.991226
19	1.278753	39	1.591064	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	1,000000

LONDON;
Printed for *Richard Mount*, at the Postern on *Tower-Hill*, 1700.

(8)

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
101	004321	004751	005181	005609	006038	006466	006894	007321	007748	008174	428
102	008600	009026	009451	009876	010299	010724	011147	011570	011993	012415	424
103	012837	013259	013679	014100	014521	014940	015359	015779	016197	016616	416
104	017033	017451	017868	018284	018700	019116	019532	019947	020361	020775	416
105	021189	021603	022016	022428	022841	023252	023664	024075	024486	024896	412
106	025306	025715	026125	026533	026942	027349	027757	028164	028571	028978	408
107	029384	029789	030195	030599	031004	031408	031812	032216	032619	033021	404
108	033424	033826	034227	034628	035029	035429	035829	036229	036629	037028	400
109	037426	037825	038223	038620	039017	039414	039811	040207	040602	040998	396
110	041393	041787	042182	042576	042969	043362	043755	044148	044539	044932	393
111	045323	045714	046105	046495	046885	047275	047664	048053	048442	048830	389
112	049218	049603	049993	050379	050766	051153	051538	051924	052309	052694	386
113	053078	053466	053846	054229	054613	054996	055378	055760	056142	056524	382
114	056905	057283	057663	058046	058426	058805	059185	059563	059942	060320	379
115	060698	061075	061452	061829	062206	062582	062958	063333	063709	064083	376
116	064458	064832	065206	065579	065593	066326	066699	067071	067443	067815	372
117	068186	068557	068928	069298	069668	070038	070407	070776	071145	071514	369
118	071882	072249	072617	072985	073352	073718	074085	074451	074816	075182	366
119	075547	075912	076276	076640	077004	077368	077731	078094	074857	078819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
121	082785	083144	083503	083861	084219	084576	084934	085291	085647	086004	357
122	086359	086716	087071	087426	087781	088136	088490	088845	089198	089552	355
123	089905	090258	090610	090963	091315	091667	092018	092369	092721	093071	351
124	093422	093772	094122	094471	094820	095169	095518	095866	096215	096562	349
125	096910	097257	097604	097951	098298	098644	098989	099335	099681	100026	346
126	100371	100715	101059	101403	101747	102091	102434	102777	103119	103462	343
127	103804	104146	104487	104828	105169	105510	105851	106191	106531	106871	340
128	107209	107545	107888	108227	108565	108903	109241	109579	109916	110253	338
129	100589	110926	111263	111599	111934	112269	112605	112939	113275	113609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116939	333
131	117271	117603	117934	118265	118595	118926	119256	119586	119915	120245	330
132	120574	120903	121231	121559	121888	122216	122544	122871	123198	123525	328
133	123852	124178	124504	124830	125156	125481	125806	126131	126456	126781	325
134	127105	127429	127753	128076	128399	128722	129045	129368	129689	130012	323
135	130334	130655	130977	131298	131619	131939	132259	132579	132899	133219	321
136	133539	133858	134177	134496	134814	135133	135451	135769	136086	136403	318
137	136721	136077	137354	137671	137987	138303	138618	138934	139249	139564	315
138	139879	140194	140508	140822	141136	141449	141763	142076	142389	142702	314
139	143015	143327	143639	143951	144263	144574	144885	145196	145507	145818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
141	149219	149527	149835	150142	150449	150756	151063	151369	151676	151982	307
142	152288	152594	152899	153205	153509	153815	154119	154423	154728	155032	305
143	155336	155639	155943	156246	156549	156852	157154	157457	157759	158061	303
144	158362	158664	158965	159266	159567	159868	160168	160469	160769	161068	301
145	161368	161667	161967	162266	162564	162863	163161	163459	163758	164055	299
146	164353	164650	164947	165244	165541	165838	166134	166430	166726	167022	297
147	167317	167613	167908	168203	168497	168792	169086	169380	169674	169968	295
148	170262	170555	170848	171142	171434	171726	172019	172311	172603	172895	293
149	172186	173478	173769	174059	174351	174641	174932	175222	175512	175802	291

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
150	176091	176381	176669	176959	177248	177536	177825	178113	178401	178689	289
151	178977	179264	179552	179839	180126	180413	180699	180986	181272	181558	287
152	181844	182129	182415	182699	182985	183269	183555	183819	184123	184407	285
153	184691	184975	185259	185542	185825	186108	186391	186674	186956	187239	283
154	187521	187803	188084	188366	188647	188928	189209	189490	189771	190051	281
155	190332	190612	190892	191171	191451	191730	192049	192289	192567	192846	279
156	193125	193403	193681	193959	194237	194514	194792	195069	195346	195623	278
157	195899	196176	196453	196729	197005	197281	197556	197832	198107	198382	276
158	198657	198932	199206	199481	199755	200029	200303	200577	200850	201124	274
159	201397	201670	201943	202216	202488	202761	203033	203303	203577	203848	272
160	204119	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
161	206826	207096	207365	207643	207904	208173	208441	208710	108978	209247	269
162	209515	209783	210051	210319	210586	210853	211121	211388	211654	211921	267
163	212187	212454	212720	212986	213252	213518	213783	214049	214314	214579	266
164	214844	215109	215323	215638	215902	216166	216429	216694	216957	217221	264
165	217484	217747	218010	218273	218536	218798	219060	219323	219585	219846	262
166	220108	220369	220631	220892	221513	221414	221675	221936	222196	222456	261
167	222716	222676	223236	223496	223755	224015	224274	224533	224791	225051	259
168	225309	225568	225827	226084	226342	226599	226858	227115	221372	227629	258
169	227887	228142	228400	228657	228913	229169	229426	229682	229938	230193	256
170	230449	230704	230959	231215	231469	231724	231979	232234	232488	232732	254
171	232996	233250	233504	233757	234011	234264	234517	234770	235023	235276	253
172	235528	235781	236033	236285	236537	236789	237041	237292	237544	237795	252
173	238046	238297	238548	238799	239049	239929	239549	239799	240049	240299	250
174	240549	240799	241048	241297	241546	241795	242044	242293	242541	242789	249
175	243038	243286	243534	243782	244029	244277	244525	244772	245019	245266	248
176	245513	245759	246009	246252	246499	246745	246991	247237	247482	247728	246
177	247973	248219	248464	248709	248954	249198	249443	249687	249932	250176	245
178	250420	250664	250908	251151	251395	251638	251881	252125	252368	252610	243
179	252853	253096	253334	253580	253822	254064	254306	254548	254789	255031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257438	241
181	257679	257918	258158	258398	258637	258877	259116	250355	259594	259833	239
182	260071	260309	260548	260787	261025	261263	261501	261739	261976	262214	238
183	262451	262688	262925	263162	263399	263636	263873	164109	164346	264582	237
184	264818	265054	265289	265525	265761	265996	266232	266467	266702	266937	235
185	267172	267406	267641	267875	168109	168344	268578	268812	269046	269279	234
186	269513	269746	269979	270213	270446	270679	270912	271144	271377	271609	233
187	271842	272074	272306	272538	272769	273001	273233	273464	273696	273927	232
188	274158	274389	274619	274850	275081	275311	275542	275772	276002	276232	230
189	276462	276692	276921	277151	277379	277609	277838	278067	278296	278525	229
190	278754	278982	279211	279439	276667	279895	280123	280351	280578	280806	228
191	281033	281261	281488	281714	281942	282169	282396	282622	282849	283075	228
192	283301	283527	283753	283979	284205	284431	284656	284882	285107	285332	226
193	285557	285782	286007	286232	286456	286681	286905	287129	287354	287578	225
194	287802	288026	288249	288473	288696	288919	289143	289366	289589	289812	223
195	290035	290257	290479	290702	290925	291147	291369	291591	291813	292034	222
196	292256	292478	292699	292920	293141	293362	293584	293804	294025	294246	221
197	294466	294687	294907	295127	295347	295567	295787	296007	296226	296446	220
198	296665	296884	297104	297323	297542	297761	297979	298198	298416	298635	219
199	298853	299071	292289	299507	299725	299943	300161	300378	300595	300813	218

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
200	301030	301247	301464	301681	301898	302114	302331	302547	302764	302979	217
201	303196	303412	303628	303844	304059	304275	304491	304706	304921	305136	216
202	305351	305566	305781	305996	306211	306425	306639	306854	307068	307282	215
203	307496	307709	307924	308137	308351	308564	308778	308991	309204	309417	213
204	309630	309843	310056	310268	310481	310693	310906	311118	311329	311542	212
205	311754	311966	312177	312389	312600	312812	313023	313234	313445	313956	211
206	313867	314078	314289	314499	314709	314920	315130	315340	315551	315760	210
207	315970	311180	316389	316599	316809	317018	317227	317436	317646	31785[illegible]	209
208	318063	318272	318481	318689	318898	319106	319314	319522	319730	319938	[illegible]
209	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	[illegible]
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324077	[illegible]
211	324282	324488	324694	324899	325105	325310	325516	325721	325926	326131	[illegible]
212	326336	326541	326745	326949	327155	327359	327563	327767	327972	328176	[illegible]
213	328379	328583	328787	328991	329194	329398	329601	329805	330008	330211	203
214	330414	330617	330819	331022	331225	331427	331629	331832	332034	332236	202
215	332438	332640	332842	333044	333246	333447	333649	333859	334051	334253	202
216	334454	334655	334856	335057	335257	335458	335658	335859	336059	336259	201
217	336459	336659	336859	337059	337259	337459	337659	337859	338058	338257	200
218	338456	338656	338856	339054	339253	339453	339650	339849	340047	330246	199
219	340444	340642	340841	341039	341237	341435	341632	241830	342028	342225	198
220	342227	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
221	344392	344589	344785	344981	345178	345737	335569	345766	345962	346157	196
222	346353	346549	346744	346939	347135	347330	347525	347720	347915	348110	195
223	348305	348499	348694	348889	349083	349278	349472	349659	349860	350054	194
224	350248	350442	350636	350829	351023	351216	351409	351604	351796	351989	193
225	352183	352375	352568	352761	352954	353147	353339	353532	353724	353916	193
226	354108	354301	354493	354685	354876	355068	355259	355452	355643	355834	192
227	356026	356217	356408	356599	356792	356981	357172	357363	357554	357744	191
228	357935	358125	358506	358699	358696	358886	359076	359266	359456	359646	190
229	359835	360025	360404	360593	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
231	363612	363799	363988	364176	364363	364551	364739	364926	365113	365301	188
232	365488	365675	365862	366049	366236	366423	366609	366796	366983	367169	187
233	367356	367542	367729	367915	368101	368287	368473	368659	368845	369030	186
234	369216	369401	369587	369772	369958	370143	370328	370513	370698	370882	185
235	371068	371253	371437	371622	371806	371991	372175	372359	372544	372728	184
236	372912	373096	373279	373464	373647	373831	374015	374198	374382	374565	184
237	374748	374932	375115	375298	375481	375664	375846	376029	376212	376394	183
238	376577	376159	376942	377124	377306	377488	377679	377852	378034	378216	182
239	378398	378579	378761	378943	379124	379306	379487	379668	379849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
241	382017	382197	382377	382557	382737	382917	383097	383277	383456	383636	180
242	383815	383995	384174	384353	384533	384712	384891	385069	385249	385428	179
243	385606	385785	385964	386142	386321	389499	386677	386856	387034	387212	178
244	387389	387568	387746	387923	388101	388279	388456	388634	388811	388989	178
245	389166	389343	389520	389698	389875	390051	390228	390405	390582	390759	177
246	390935	391112	391288	391464	391641	391817	391993	392169	392345	392521	176
247	392697	392873	393048	393224	393399	393575	393751	393926	394101	394277	176
248	394452	394627	394802	394977	395152	395326	395501	395676	395850	396025	175
249	396199	396374	396548	396722	396896	397071	397245	397419	397592	397766	174

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
251	399674	399847	400019	400192	400365	400538	400711	400883	401056	401228	173
252	401401	401573	401745	401917	402089	402261	402433	402605	402777	402949	172
253	403121	403292	403464	403635	403807	403978	404149	404320	404492	404663	171
254	404834	405005	405176	405346	405517	405688	405858	406029	406199	406369	171
255	406540	406710	406881	407051	407221	407391	407561	407731	407901	408070	170
256	408239	408409	408579	408749	408918	409087	409257	409426	409595	409764	169
257	409933	410102	410271	410439	410609	410777	410946	411114	411283	411451	169
258	411619	411788	411956	412124	412293	412461	412629	412796	412964	413132	168
259	413299	413467	413635	413803	413969	413137	413305	414472	414639	414806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
261	416641	416807	416973	417139	417306	417472	417638	417804	417969	418135	166
262	418301	418467	418633	418798	418964	419129	419295	419460	419625	419791	165
263	419956	420121	420289	420451	420616	420781	420945	421110	421275	421439	165
264	421604	421768	421933	422097	422261	422426	422589	422754	422918	423082	164
265	423246	423409	423574	423737	423901	424065	424228	424392	424555	424718	164
266	424882	425045	425208	425371	425534	425697	425860	426023	426186	426349	163
267	426511	426674	426836	426999	427161	427324	427486	427648	427811	427973	162
268	428135	428297	428459	428621	428783	428944	429106	429268	429429	429591	162
269	429752	429914	430075	430236	430398	430559	430719	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
271	432969	433129	433289	433449	433609	433769	433929	434089	434249	434409	160
272	434569	434729	434888	435048	435207	435366	435526	435685	435844	436004	159
273	436163	436322	436481	436639	436799	436957	437116	437275	437433	437592	159
274	437751	437909	438067	438226	438384	438542	438701	438859	439017	439175	158
275	439333	439491	439648	439806	439964	440122	440279	440437	440594	440752	158
276	440909	441066	441224	441381	441538	441695	441852	442009	442166	442323	157
277	442479	442637	442793	442949	443106	443263	443419	443576	443732	443889	157
278	444045	444201	444357	444513	444669	444825	444981	445137	445293	445449	156
279	445604	445759	445915	446071	446226	446382	446537	446692	446848	447003	155
280	447158	447313	447468	447623	447778	447932	448088	448242	448397	448552	155
281	448706	448861	449015	449169	449324	449478	449633	449787	449941	450095	154
282	450249	450403	450557	450711	450865	451018	451172	451326	451479	451633	154
283	451786	451939	452093	452247	452399	452553	452706	452859	453012	453165	153
284	453318	453471	453624	453777	453929	454082	454235	454387	454539	454692	153
285	454845	454997	455149	455302	455454	455606	455758	455910	456062	456214	152
286	456366	456518	456669	456821	456973	457125	457276	457428	457579	457731	152
287	459889	458033	458184	458336	458487	458638	458789	458939	459091	459242	151
288	459392	459543	459694	459845	459995	460146	460296	460447	460597	460748	151
289	460898	461048	461198	461348	461499	461649	461799	461948	462098	462248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
291	463893	464042	464191	464340	464489	464639	464787	464936	465085	465234	149
292	465383	465532	465680	465829	465977	466126	466274	466423	466571	466719	149
293	466868	467016	467164	467312	467460	467608	467756	467904	468052	468199	148
294	468347	468495	468643	468790	468798	469085	469233	469380	469527	469675	147
295	469822	469969	470116	470263	470410	470557	470704	470851	470998	471145	147
296	471292	471438	471585	471732	471878	472025	472171	472318	472464	472610	146
297	472756	472903	473049	473195	473341	473487	473633	473779	473925	474071	146
298	474216	474362	474508	474653	474799	474944	475089	475235	475381	475526	146
299	475671	475816	475962	476107	476252	476397	476542	476687	476832	476076	145

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300	477121	477266	477411	477555	477699	477844	477989	478133	478278	478422	145
301	478566	478711	478855	478999	479143	479287	479431	479575	479719	479863	144
302	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
303	481443	481586	481729	481872	482016	482159	482302	482445	482588	482731	143
304	482874	483016	483159	483302	483445	483587	483729	483872	484015	484157	143
305	484299	484442	484585	484727	484869	485011	485153	485295	485437	485579	142
306	485721	485863	486005	486147	486289	486430	486572	486714	486855	486997	142
307	487138	487279	487421	487563	487704	487845	487986	488127	488269	488409	141
308	488551	488692	488833	488974	489114	489255	489396	489537	489677	489818	141
309	489958	490099	490239	490379	490520	490661	490801	490941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
311	492760	492900	493039	493179	493319	493458	493597	493737	493876	494015	139
312	494155	494294	494433	494572	494711	494850	494989	495128	495267	495406	139
313	495544	495683	495822	495960	496099	496238	496376	496515	496653	496791	139
314	496929	497068	497206	497344	497483	497621	497759	497897	498035	498173	138
315	498311	498448	498586	498724	498862	498999	499137	499275	499412	499549	138
316	499687	499824	499962	500099	500236	500374	500510	500648	500785	500922	137
317	501059	501196	501333	501470	501607	501744	501880	502017	502154	502291	137
318	502427	502564	502700	502837	502973	503109	503246	503382	503518	503655	136
319	503791	503927	504063	504199	504335	504471	504607	504743	504878	505014	136
320	505149	505286	505421	505557	505693	505828	505964	506099	506234	506369	136
321	506505	506640	506776	506911	507046	507181	507316	507451	507586	507721	135
322	507856	507991	508126	508260	508395	508529	508664	508799	508934	509068	135
323	509203	509337	509471	509606	509740	509874	510009	510143	510277	510411	134
324	510545	610679	510813	510947	511081	511215	511349	511482	511616	511749	134
325	511883	512017	512151	512284	512418	512551	512684	512818	512951	513084	133
326	513218	513351	513484	513617	513750	513883	514016	514149	514282	514415	133
327	514548	514681	514813	514946	515079	515211	515344	515476	515609	515741	133
328	515874	516006	516139	516271	516403	516535	516668	516799	516932	517064	132
329	517196	517328	517459	517592	517724	517855	517987	518119	518251	518382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
331	519828	519959	520090	520221	520353	520484	520615	520745	520876	521007	131
332	521138	521269	521399	521530	521661	521792	521922	522053	522183	522314	131
333	522444	522575	522705	522835	522966	523096	523226	523356	523486	523616	130
334	523746	523876	524006	524136	524266	524396	524526	524656	524785	524915	130
335	525045	525174	525304	525434	525563	525693	525822	525951	526081	526210	129
336	526339	526469	526598	526727	526856	526985	527114	527243	527372	527501	129
337	527629	527759	527888	528016	528145	528274	528402	528531	528659	528788	129
338	528916	529045	529174	529302	529430	529559	529687	529815	529943	530072	128
339	530199	530328	530456	530584	530712	530839	530968	531096	531223	531351	128
340	531479	531607	531734	531862	531989	532117	532245	532372	532499	532627	128
341	532754	532882	533009	533136	533264	533391	533518	533645	533772	533899	127
342	534026	534153	534280	534407	534534	534661	534787	534914	535041	535167	127
343	535294	535421	535547	535674	535800	535927	536053	536179	536304	536432	126
344	536558	536685	536811	536937	537063	537189	537315	537441	537567	537693	126
345	537819	537945	538071	538197	538322	538448	538574	538699	538825	538951	126
346	539076	539202	539327	539452	539578	539703	539829	539954	540079	540204	125
347	540329	540455	540579	540705	540829	540955	541079	541205	541329	541454	125
348	541579	541704	541829	541953	542078	542203	542327	542452	542576	542701	125
349	542825	542949	543074	543199	543323	543447	543571	543696	543819	543944	124

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350	544008	544192	544316	544440	544564	544688	544812	544934	545059	545183	124
351	545307	545431	545555	545678	545802	545925	546049	546172	546296	546419	124
352	546543	546666	546789	546913	547036	547159	547282	547405	547529	547652	123
353	547775	547898	548021	548144	548267	548389	548512	548635	548758	548881	123
354	549003	549126	549249	549371	549494	549616	549739	549861	549984	550106	123
355	550228	550351	550473	550595	550717	550839	550962	551084	551206	551328	122
356	551449	551572	551694	551816	551938	552059	552181	552303	552425	552547	122
357	552668	552789	552911	553033	553155	553276	553398	553519	553640	553762	121
358	553883	554004	554126	554247	554368	554489	554610	554731	554852	554973	121
359	555094	555215	555336	554457	555578	555699	555819	555940	556061	556182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
361	557507	557627	557748	557868	557988	558108	558228	558349	558469	558589	120
362	558709	558829	558948	559068	559188	559308	559428	559548	559667	559787	120
363	559907	560026	560146	560265	560385	560504	560624	560743	560863	560982	119
364	561101	561221	561339	561459	561578	561698	561817	561936	562055	562174	119
365	562293	562412	562531	562649	562769	562887	563006	563125	563244	563362	119
366	563481	563599	563718	563837	563955	564074	564192	564311	564429	564548	119
367	564666	564784	564903	565021	565139	565257	565376	565494	565612	565729	118
368	565848	565966	566084	566202	566319	566437	566555	566673	566791	566909	118
369	567026	567144	567262	567379	567497	567614	567732	567849	567967	568084	118
370	568202	568319	568436	568554	568671	568788	568905	596023	596131	569257	117
371	569374	569491	569608	569725	569842	569959	570076	570193	570309	570426	117
372	570543	570659	570776	570893	571009	571126	571243	571359	571476	571592	117
373	571709	571825	571942	572058	572174	572291	572407	572523	572639	572755	116
374	572872	572988	573104	573219	573339	573452	573568	573684	573799	573915	116
375	574031	574147	574263	574379	574494	574609	574726	574841	574957	575072	116
376	575188	575303	575419	575534	575649	575765	575880	575996	576111	576226	115
377	576341	576457	576572	576687	576802	576917	577032	577147	577262	577377	115
378	577492	577607	577722	577836	577951	578066	578181	578295	578409	578525	115
379	578639	578754	578868	578983	579097	579212	579326	579441	579555	579669	114
380	579784	579898	580012	580126	580241	580355	580469	580583	580697	580811	114
381	580925	581039	581153	581267	581381	581495	581608	581722	581836	581949	114
382	582063	582177	582291	582404	582518	582631	582745	582858	582972	583085	114
383	583199	583312	583426	583539	583652	583765	583876	583992	584105	584218	113
384	584331	584444	584587	584670	584783	584896	585009	585122	585235	585348	113
385	585461	585574	585686	585799	585912	586024	586137	586249	586362	586475	113
386	586587	586699	586812	586925	587037	587149	587262	587374	587486	587599	112
387	587711	587823	587935	588047	588159	588272	588384	588496	588608	588719	112
388	588832	588944	589056	589167	589279	589391	589503	589615	589726	589838	112
389	589949	590061	590173	590284	590396	590507	590619	590730	590842	590953	112
390	591065	591176	591287	591399	591509	591621	591732	591843	591955	592066	111
391	592177	592288	592399	592505	592621	592732	592843	592954	593064	593175	111
392	593286	593397	593508	593618	593729	593839	593950	594061	594171	594282	111
393	594393	594503	594614	594724	594834	594945	595055	595165	595276	595386	110
394	595496	595606	595717	595827	595937	596047	596157	596267	596377	596487	110
395	596597	596707	596817	596927	597037	597146	597256	597366	597476	597586	110
396	597695	597805	597914	598024	598134	598243	598353	598462	598572	598681	110
397	598790	598899	599009	599119	599228	599337	599446	599556	599665	599774	109
398	599883	599992	600101	600210	600319	600428	600537	600646	600755	600864	109
399	600973	601082	601191	601299	601408	601517	601625	601734	601842	601951	109

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401	603144	603253	603361	603469	603577	603686	603794	603902	604009	604118	108
402	604226	604334	604442	604550	604658	604766	604874	604982	605089	605197	108
403	605305	605413	605521	605628	605736	605844	605951	606059	606166	606274	108
404	606381	606489	606596	606704	606811	606919	607026	607133	607241	607348	107
405	607455	607562	607669	607777	607884	607991	608098	608205	608312	608419	107
406	608526	608633	608739	608847	608954	609061	609167	609274	609381	609488	107
407	609594	609701	609808	609914	610021	610128	610234	610341	610447	610555	107
408	610660	620767	610873	610979	611086	611192	611298	611405	611511	611617	106
409	611723	621829	611936	612042	612148	612254	612359	612466	612572	612678	106
410	612784	612889	612966	613102	613207	613313	613419	613525	613630	613736	106
411	613842	613947	614053	614159	614264	614369	614475	614581	614686	614792	106
412	614807	615003	615108	615213	615319	615424	615529	615634	615739	615845	105
413	615950	616055	616160	616265	616370	616476	616581	616686	616790	616895	105
414	617000	617105	617210	617315	617419	617525	617629	617734	617839	617943	105
415	618048	618153	618257	618362	618466	618571	618676	618780	618889	618989	105
416	619093	619198	619302	619406	619511	619615	619719	619824	619928	620032	104
417	620136	620240	620344	620448	620552	620656	620760	620864	620968	621072	104
418	621176	621280	621384	621448	621592	621695	621799	621902	622007	622110	104
419	622214	622317	622421	622525	622628	622722	622835	622939	623042	623146	104
420	623249	623353	623456	623559	623663	623766	623869	623973	624076	624179	103
421	624282	624385	624488	624591	624695	624798	624901	625004	625107	625209	103
422	625312	625415	625518	625621	625424	625827	625929	626032	626135	626237	103
423	626340	626443	626546	626648	626751	626853	626956	627058	627161	627263	103
424	627366	627468	627571	627673	627775	627878	627979	628082	628185	628287	102
425	628389	628491	628593	628695	628797	628899	629002	629194	629206	629308	102
426	629409	629512	629613	629715	629817	629919	630021	630123	630224	630326	102
427	630428	630529	630631	630733	630835	630936	631038	631139	631241	631342	102
428	631444	631549	631647	631748	631849	631951	632052	632153	632255	632356	101
429	632457	632559	932659	632761	632862	632963	633064	633165	633266	633367	101
430	633468	633569	633670	633771	633872	633973	634075	634175	634276	634376	100
431	634477	634578	634679	634779	634880	634981	635081	635182	635283	635383	100
432	635484	635584	635685	635785	635886	635986	636087	636187	636288	636388	100
433	636488	636588	636688	636789	636889	636989	637089	637189	637289	637389	100
434	637489	637589	637689	637789	637889	637989	638089	638189	638289	638389	99
435	638489	638589	638689	638789	638888	638988	639088	639188	639287	639387	99
436	639486	639586	639686	639785	539885	639984	640084	640183	640283	640382	99
437	640481	640581	640680	640779	640879	640978	641077	641177	641276	641375	99
438	641435	641573	641672	641771	641871	641969	642069	642168	642267	642366	99
439	642465	642563	642662	642761	642860	642959	643058	643156	643255	643354	99
440	643453	643551	643650	643749	643847	643946	644044	644143	644242	644340	98
441	644439	644537	644636	644734	644833	644931	645029	645127	645226	545324	98
442	645422	645521	645619	645717	645815	645913	646011	646109	646208	646306	98
443	646404	646502	646599	646698	646796	646894	646992	647089	647187	647285	98
444	647383	647481	647579	647676	647774	647872	647969	648067	648165	648262	98
445	548360	648458	648555	648653	648750	648848	648945	649043	649140	649237	97
446	649335	649432	649529	649627	649724	649821	649919	650016	650113	650210	97
447	650308	650405	650502	650599	650696	650793	650890	650987	651084	651181	97
448	651278	651375	651472	651569	651666	651762	651859	651956	652053	652149	97
449	652246	652342	652439	652536	652633	652729	652826	652923	653019	653116	97

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450	653213	653309	653405	653502	653598	653695	653791	653888	653984	654080	96
451	654177	654273	654369	654465	654562	654658	654754	654850	654946	655042	96
452	655138	655235	655331	655427	655523	655619	655715	655810	655906	656002	96
453	656098	656194	656289	656386	656482	656577	656673	656769	656864	656960	96
454	657056	657152	657247	657343	657438	657534	657629	657725	657820	657916	96
455	658011	658107	658202	658298	658393	658488	658584	658679	658774	658869	95
456	658965	659060	659155	659250	659346	659441	659536	659630	659726	659821	95
457	659916	660011	660106	660201	660296	660391	660486	660581	660676	660771	95
458	660865	660960	661055	661149	661245	661339	661434	661529	661623	661718	95
459	661813	661907	662002	662096	662191	662286	662380	662475	662569	662663	95
460	662758	662852	662947	663041	663135	663229	663324	663418	663512	663607	94
461	663701	663795	663889	663983	664078	664172	664266	664359	664454	664548	94
462	664642	664736	664829	664924	665018	665112	665206	665299	665393	665487	94
463	665581	665675	665769	665862	665956	666049	666143	666237	666331	666424	94
464	666518	666611	666705	666799	666892	666986	667079	667173	667266	667359	94
465	667453	667546	667639	667733	667826	667919	668013	668106	668199	668293	93
466	668386	668479	668572	668665	668759	668852	668945	669038	669131	669224	93
467	669317	669409	669503	669596	669689	669782	669875	669967	670060	670153	93
468	670246	670339	670431	670524	670617	670709	670802	670895	670988	671080	93
469	671173	671265	671358	671451	671543	671636	971728	671821	671913	672005	93
470	672098	672190	672283	672375	672467	672559	672652	672744	672836	672929	92
471	673021	673113	673205	673297	673389	673482	673574	673666	673758	673849	92
472	673942	674034	674126	674218	674309	674402	674494	674586	674677	674769	92
473	674861	674959	675045	675137	675228	675319	675412	675503	675595	675687	92
474	675778	675869	675962	676053	676145	676236	676328	676419	676511	676602	92
475	676694	676785	676876	676968	677059	677151	677242	677333	677424	677516	91
476	677607	677698	677789	677881	677972	678063	678154	67824[illegible]	678335	678427	91
477	678518	678609	678700	678791	678882	678973	679064	679155	679246	679337	91
478	679428	679519	679609	679700	679791	679882	679972	680063	680154	680245	91
479	680336	680426	680517	680607	680698	680789	680879	680969	681060	681151	91
480	681241	681332	681422	681513	681603	681693	681784	681874	681964	682055	90
481	682145	682235	682326	682416	682506	682596	682686	682777	682867	682957	90
482	683047	683137	683227	683317	583407	683497	683587	683677	683767	683857	90
483	683947	684037	684127	684217	684307	684396	684486	684576	684666	684756	90
484	684845	684935	685025	685114	685204	685294	685383	685473	685563	685652	90
485	685742	685831	685921	686010	686099	686189	686279	686368	686458	686547	89
486	686636	686726	686815	686904	686994	687083	687172	687261	687351	687439	89
487	687529	687618	687707	687796	587885	687975	688064	688153	688242	688331	89
488	688419	688509	688598	688687	988776	688865	688953	689042	689131	689220	89
489	689309	689398	689486	689575	689664	689753	689841	689930	690019	690107	89
490	690196	690285	690373	690462	690550	690639	690728	690816	690905	690993	89
491	691081	691169	691258	691347	691435	691524	691612	691700	691789	691877	88
492	691965	692053	692142	692229	692318	692406	692494	692583	692671	692759	88
493	692847	692935	693023	893111	693199	693287	693375	693463	693551	693639	88
494	693727	693815	693903	693991	694078	694166	694254	694342	694429	694517	88
495	694605	694693	694781	694868	594956	695044	695131	695219	695307	695394	88
496	695482	695569	695657	695744	595832	695919	696007	696094	696182	696269	87
497	596356	696444	696531	696618	596706	696793	696880	696968	697055	6971[illegible]	87
498	697229	697317	697404	697491	597578	697665	697752	697839	697926	698014	87
499	698101	698188	698275	698362	598449	698535	698622	698709	698796	698883	87

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502	700704	700790	700877	700963	701049	701136	701222	701309	701395	701482	86
503	701568	701654	701741	701827	701913	701999	702086	702172	702258	702344	86
504	702430	702517	702603	702689	702775	702861	702947	703033	703119	703205	86
505	703291	703377	703463	703549	703635	703721	703807	703893	703979	704065	86
506	704151	704236	704322	704408	704494	704579	704665	704751	704837	704922	86
507	705008	705094	705179	705265	705350	705436	705522	705607	705693	705778	86
508	705863	705949	706035	706120	706206	706291	706376	706462	706547	706632	85
509	706718	706803	706888	706974	707059	707144	707219	707315	707399	707485	85
510	707570	707655	707740	707826	707911	707996	708081	708166	708251	708336	85
511	708421	708506	708591	708676	708761	708846	708931	709015	709100	709185	85
512	709269	709355	709439	709524	709609	709694	709779	709863	709948	710033	85
513	710117	710202	710287	710371	710456	710540	710625	710709	710794	710879	85
514	710963	711048	711132	711217	711301	711385	711469	711554	711639	711723	84
515	711807	711892	711976	712060	712144	712229	712313	712397	712481	712566	84
516	712649	712734	712818	712902	712986	713070	713154	713238	713223	713407	84
517	713491	713575	713659	713742	713826	713910	713994	714078	714162	714246	84
518	714329	714415	714497	714581	714665	714749	714833	714916	714999	714084	84
519	715167	715251	715335	715418	715501	715586	715669	715753	715836	715919	84
520	716003	716087	716170	716254	716337	716421	716504	716588	716671	716754	83
521	716838	716921	717004	717088	717171	717254	717338	717421	717504	717587	83
522	717671	717754	717837	717920	718003	718086	718169	718253	718336	718419	83
523	718502	718585	718668	718751	718834	718917	718999	719083	719165	719248	83
524	719331	719414	719497	719579	719663	719745	719828	719911	719994	720077	83
525	720159	720242	720325	720407	720490	720573	720655	720738	720821	720903	83
526	720986	721068	721151	721233	721316	721398	721481	721563	721646	721728	82
527	721811	721893	721975	722058	722140	722222	722305	722387	722469	722552	82
528	722634	722716	722798	722881	722963	723045	723127	723209	723291	723374	82
529	723456	723538	723619	723702	723784	723866	723948	724029	724112	724194	82
530	724276	724358	724439	724522	724604	724685	724767	724849	724931	725013	82
531	725095	725176	725258	725339	725422	725503	725585	725667	725748	725829	82
532	725912	725993	726075	726156	726238	726319	726401	726483	726564	726646	82
533	726727	726809	726890	726972	727053	727134	727216	727297	727379	727459	81
534	727541	727623	727704	727785	727866	727948	728029	728110	728191	728273	81
535	728354	728435	728516	728597	728678	728759	728841	728922	729003	729084	81
536	729165	729246	729327	729408	729489	729569	729651	729732	729813	729893	81
537	729974	730055	730136	730217	730298	730378	730459	730540	730621	730702	81
538	730782	730863	730944	731024	731105	731186	731266	731347	731423	731508	81
539	731589	731669	731749	731830	731911	731991	732072	732152	732233	732313	81
540	732394	732474	732555	732635	732715	732796	732876	732956	733037	733117	80
541	733197	733278	733358	733438	733518	733598	733679	733759	733839	733919	80
542	733999	734079	734159	734239	734319	734399	734479	734559	734639	734719	80
543	734799	734879	734959	735039	735119	735199	735279	735359	735439	795519	80
544	735599	735679	735759	735838	735918	735998	736078	736157	736237	736317	80
545	736397	736476	736556	736635	736715	736795	736874	736954	737034	737113	80
546	737192	737272	737352	737431	737511	737590	737669	737749	737829	737908	79
547	737987	738067	738146	738225	738305	738384	738463	738543	738622	738701	79
548	738781	738859	738939	739018	739097	739177	739259	739335	739414	739493	79
549	739572	739651	739731	539809	739889	739968	740047	740126	740205	740284	79

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551	741152	741230	741309	741388	741467	741546	741624	741703	741782	741860	79
552	741939	742018	742096	742175	742254	742332	742411	742489	742568	742647	79
553	742725	742802	742882	742961	743039	743118	743196	743275	743353	743431	78
554	743509	743588	743667	743745	743823	743902	743979	744058	744136	744215	78
555	744293	744371	744449	744528	744606	744684	744762	744840	744919	744997	78
556	745075	745153	745231	745309	745387	745465	745543	745621	745699	745777	78
557	745855	745933	746011	746089	746167	746245	746323	746401	746479	746556	78
558	746634	746712	746789	746868	746945	747023	747101	747179	747256	747334	78
559	747412	747489	747567	747645	747712	747800	747878	747955	748033	748110	78
560	748188	748266	748343	748421	748498	748576	748653	748731	748808	748885	77
561	748963	749040	749118	749195	749272	759349	749427	749504	749582	749659	77
562	749736	749814	749891	749968	750045	750123	750199	750277	750354	750431	77
563	750508	750586	750663	750739	750817	750894	750971	751048	751125	751202	77
564	751279	751356	751433	751510	751587	751664	751741	751818	751895	751972	77
565	752048	752125	752202	752279	752356	752433	752509	752586	752663	752739	77
566	752816	752893	752969	753047	753123	753199	753277	753353	753429	753506	77
567	753583	753659	753736	753813	753889	753966	754042	754119	754195	754272	77
568	754348	754425	754501	754578	754654	754730	754807	754883	754959	755036	76
569	755112	755189	755265	755341	755417	755494	755569	755646	755722	755799	76
570	755875	755951	756027	756103	756179	756256	756332	756408	756484	756560	76
571	756636	756712	756788	756864	756940	757016	757092	757168	757244	757320	76
572	757396	757472	757548	757624	757699	757775	757851	757927	758003	758079	76
573	758155	758230	758306	758382	758458	758533	758609	758685	758761	758836	76
574	758912	758988	759063	759139	759214	759290	759366	759441	759517	759592	76
575	759668	759743	759819	759894	759969	760045	760121	760196	760272	760347	75
576	760422	760498	760573	760649	760723	760799	760875	760949	761025	761101	75
577	761176	761251	761326	761402	761477	761552	761627	761702	761778	761853	75
578	761928	762003	762078	762153	762228	762303	762378	762453	762529	762604	75
579	762679	762754	762829	762904	762978	763053	763128	763203	763279	763353	75
580	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
581	764176	764251	764326	764400	764475	764549	764624	764699	764774	764848	75
582	764923	764998	765072	765147	765221	765296	765370	765445	765519	765594	75
583	765669	765743	765818	765892	765966	766041	766115	766189	766264	766338	74
584	766413	766487	766562	766636	766710	766785	766859	766933	767007	767082	74
585	767156	767230	767304	767379	767453	767527	767601	767675	767749	767823	74
586	767898	767972	768046	768119	768194	768268	768342	768416	768490	768564	74
587	768638	768712	768786	768860	768934	769008	769082	769156	769229	769303	74
588	769377	769451	769525	769599	769673	769746	769820	760894	769968	770042	74
589	770115	770189	770263	770336	770410	770484	770557	770631	770705	770778	74
590	770852	770926	770999	771073	771146	771219	771293	771367	771440	771514	74
591	771587	771661	771734	771808	771881	771955	772028	772102	772175	772248	73
592	772322	772395	772468	772542	772615	772688	772762	772835	772908	772981	73
593	773055	773128	773201	773274	773348	773421	773494	773567	773640	773713	73
594	773786	773859	773933	774006	774079	774152	774225	774298	774371	774444	73
595	774517	774589	774663	774736	774809	774882	774955	775028	775100	775173	73
596	775246	775319	775392	775465	775538	775610	775683	775756	775829	775902	73
597	775974	776047	776119	776193	776265	776338	776411	776483	[illegible]	776629	73
598	776701	776774	776846	776919	776992	777064	777137	777209	777282	777354	73
599	777427	777499	777572	777644	777717	777789	777862	777934	778006	778070	73

The Table of Logarithms.

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601	778874	778947	779019	779091	779163	779236	779308	779380	779452	779524	72
602	779596	779669	779741	779813	779884	779957	780029	780101	780173	780245	72
603	780317	780389	780461	780533	780605	780677	780749	780821	780893	780965	72
604	781037	781109	781181	781253	781324	781396	781468	781539	781612	781684	72
605	781755	781827	781899	781971	782042	782114	782186	782258	782329	782801	72
606	782473	782544	782616	782688	782759	782831	782902	782974	783046	783117	72
607	783189	783260	783332	783403	783475	783546	783618	783689	783761	783832	71
608	783904	783975	784046	784118	784189	784261	784332	784403	784475	784546	71
609	784617	784689	784759	784831	784902	784974	785045	785116	785187	785259	71
610	785329	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
611	786041	786112	786183	786254	786325	786396	786467	786538	786609	786680	71
612	786751	786822	786893	786964	787035	787106	787177	787248	787319	787389	71
613	787460	787531	787602	787673	787744	787815	787885	787956	788017	788098	71
614	788164	788239	788309	788381	788451	788522	788593	788663	788734	788804	71
615	788875	788946	789016	789087	789157	789228	789299	789369	789439	789510	71
616	789581	789651	789722	789792	789863	789933	790004	790074	790144	790215	70
617	790285	790356	790426	790496	790567	790637	790707	790778	790848	790918	70
618	790988	791059	791129	791199	791269	791339	791409	791480	791550	791620	70
619	791691	791761	791831	791901	791971	792041	792111	792181	792252	792322	70
620	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
621	793092	793162	793231	793301	793371	793441	793511	793581	793651	793721	70
622	793791	793860	793930	793999	794069	794139	794209	794279	794349	794418	70
623	794488	794558	794627	794697	794767	794836	794906	794976	795045	795115	70
624	795185	795254	795324	795393	795463	795532	795602	795672	795741	795810	70
625	795880	795949	796019	796088	796158	796227	796297	796366	796436	796505	69
626	796574	796644	796713	796782	796852	796921	796990	797059	797129	797198	69
627	797268	797337	797406	797475	797545	797614	797683	797752	797821	797890	69
628	797959	798029	798098	798167	798236	798305	798374	798443	798513	798582	69
629	798651	798719	798789	798858	798927	798996	799065	799134	799203	799272	69
630	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
631	800029	800098	800167	800236	800305	800373	800442	800511	800579	800648	69
632	800717	800786	800854	800923	800992	801061	801129	801198	801266	801335	69
633	801404	801472	801541	801609	801678	801747	801815	801884	801952	802021	69
634	802089	802158	802226	802295	802363	802432	802500	802568	802637	802705	68
635	802774	802842	802910	802979	803047	803116	803184	803252	803321	803389	68
636	803457	803525	803594	803662	803730	803798	803867	803935	804003	804071	68
637	804139	804208	804276	804344	804412	804480	804548	804616	804685	804753	68
638	804821	804889	804957	805025	805093	805161	805229	805297	805365	805433	68
639	805501	805569	805637	805705	805773	805841	805908	805976	806044	806112	68
640	806179	806248	866316	806384	806451	806519	806587	806655	806723	806790	68
641	806858	806926	806994	807061	807129	807197	807264	807332	807399	807467	68
642	807535	807603	807670	807738	807806	807873	807941	808008	808076	808143	68
643	808211	808279	808346	808414	808481	808549	808616	808684	808751	808818	67
644	808886	808953	809021	809088	809156	809223	809290	809358	809425	809492	67
645	809559	809627	809694	809762	809829	809866	809964	810031	810098	810165	67
646	810233	810299	810367	810434	810501	810569	810636	810703	810770	810837	67
647	810904	810971	811039	811106	811173	811239	811307	811374	811441	811508	67
648	811575	811642	811709	811776	811843	811909	811977	812044	812111	812178	67
649	811245	812312	812379	812445	812512	812579	812646	812713	812779	812847	67

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650	812913	812980	813047	813114	813181	813247	813314	813381	813448	813514	67
651	813581	813648	813714	813781	813848	813914	813981	814048	814114	814181	67
652	814248	814314	814381	814447	814514	814581	814647	814714	814780	814847	67
653	814913	814979	815046	815113	815129	815246	815312	815378	815445	815511	66
654	815578	815644	815711	815777	815843	815909	815976	816042	816109	816175	66
655	816241	816308	816374	816440	816506	816573	816639	816705	816771	816838	66
656	816904	816916	817036	817102	817169	817235	817301	817367	817433	817499	66
657	817565	817631	817698	817764	817829	817896	817962	818028	818094	818159	66
658	818226	818292	818358	818424	818489	818556	818622	818688	818754	818819	66
659	818885	818951	819017	819083	819149	819215	819281	819346	819412	819478	66
660	819543	819609	819676	819741	819807	819873	819939	820004	820070	820136	66
661	820201	820267	820333	820399	820464	820529	820595	820661	820727	820792	66
662	820858	820924	820989	821055	821120	821186	821251	821317	821382	821448	66
663	821514	821509	821645	821709	821775	821841	821906	824972	822037	822103	65
664	822168	822233	822299	822364	822429	822495	822560	822626	822691	822756	65
665	822822	822887	822952	823018	823083	823148	823213	823279	823344	823409	65
666	823474	823539	823605	823669	823735	823800	823865	823980	823996	824061	65
667	824126	824191	824256	824321	824386	824451	824516	824581	824646	824711	65
668	824776	824841	824906	824971	825036	825101	825166	825231	825296	825361	65
669	825426	825491	825556	825621	825686	825751	825815	825880	825945	826009	65
670	826075	826139	826204	826269	826334	826399	826464	826528	826593	826658	65
671	826723	826787	826852	826917	826981	827046	827111	827175	827239	827305	65
672	827369	827434	827499	827563	827628	827692	827757	827822	827886	827951	65
673	828015	828079	828144	828209	828273	828338	828402	828467	828531	828595	64
674	828659	828724	828789	828853	828918	828988	829046	829111	829175	829239	64
675	829304	829368	829432	829497	829561	829625	829689	829754	829818	829882	64
676	829947	830011	830075	830139	830204	830268	830332	830396	830460	830525	64
677	830589	830653	830717	830781	830845	830909	830973	831037	831102	831166	64
678	831229	831294	831358	831422	831486	831549	831614	831678	831742	831806	64
679	831869	831934	831998	832062	832126	832189	832253	832317	832381	832445	64
680	832509	832573	832637	832700	832764	832828	832892	832956	833019	833083	64
681	833147	833211	833275	833338	833402	833466	833529	833593	833657	833721	64
682	833784	833848	833912	833975	834039	834103	834166	834229	834294	834357	64
683	834421	834484	834548	834611	834675	834739	834802	834866	834929	834993	64
684	835056	835119	835183	835247	835310	835373	835437	835500	835564	835627	63
685	835691	835754	835817	835881	835944	836007	836071	836134	836197	836261	63
686	836324	836387	836451	836514	836577	836641	836704	836767	836830	836894	63
687	836957	837019	83708[illegible]	837146	837209	837273	837336	837399	837462	837525	63
688	837588	837652	837715	837777	837841	837904	837967	838030	838093	838156	63
689	838219	838282	838345	838408	838471	838534	838597	838660	838723	838786	63
690	838849	838912	838975	839038	839101	839164	839227	839289	839352	839415	63
691	839478	839541	839604	839667	839729	839792	839855	839918	839981	840043	63
692	840106	840169	840232	840394	840357	840419	840482	840545	840608	840671	63
693	840733	840796	840859	840921	840984	841049	841109	841172	841234	841297	63
694	841359	841423	841485	841547	841609	841672	841735	841797	841859	841922	63
695	841985	842047	842109	842172	842235	842297	842359	842432	842484	842547	62
696	842609	842672	842734	842796	842859	842921	842983	843046	843108	843170	62
697	843233	843295	843357	843419	843482	843544	843606	843669	843731	843293	62
698	843855	843918	843979	844042	844104	844166	844229	844291	844353	844415	62
699	844477	844539	844601	844664	844726	844788	844849	844912	844974	845036	62

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700	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
701	845718	845779	845842	845904	845966	846028	846089	846151	846213	846275	62
702	846337	846399	846461	846523	846585	846646	846708	846769	846832	846894	62
703	846955	847017	847079	847141	847202	847264	847326	847388	847449	847511	62
704	847573	847634	847696	847758	847819	847881	847943	848004	848067	848128	62
705	848189	848251	848312	848374	848435	848497	848559	848620	848682	848743	62
706	848805	848866	848928	848989	849051	849112	849174	849235	849297	849358	61
707	849419	849481	849542	849604	849665	849726	849788	849849	849911	849972	61
708	850033	850095	850156	850217	850279	850339	850401	850462	850524	850585	61
709	850646	850707	850769	850829	850891	850952	851014	851075	851136	851197	61
710	851258	851319	851381	851442	851503	851564	851625	851686	851747	851809	61
711	851869	851931	851992	851053	852114	852175	852236	852297	852358	852419	61
712	852479	852541	852602	852663	852724	852785	852846	852907	852968	853029	61
713	853089	853150	853211	853272	853333	853394	853455	853516	853577	853637	61
714	853698	853759	853819	853881	853941	854002	854063	854124	854185	854245	61
715	854306	854367	854428	854488	854549	854609	854670	854731	854792	854852	61
716	854913	854974	855034	855095	855156	855216	855277	855337	855398	855459	61
717	855519	855579	855640	855701	855761	855822	855882	855943	856003	856064	61
718	856124	856185	856245	856306	856366	856427	856487	856548	856608	856668	60
719	856729	856789	856849	856910	856970	857031	857091	857152	857212	857272	60
720	857332	857393	857453	857513	857574	857634	857694	857755	857815	857875	60
721	857935	857995	858056	858116	858176	858236	858297	858357	858417	858477	60
722	858537	858597	858657	858718	858778	858838	858898	858958	859018	859078	60
723	859138	859198	859258	859318	859379	859439	859499	859559	859619	859679	60
724	859739	859799	859859	859918	859978	860038	860098	860158	860218	860278	60
725	860338	860398	860458	860518	860578	860637	860697	860757	860817	860877	60
726	860937	860996	861056	861116	861176	861236	861295	861355	861415	861475	60
727	861534	861594	861654	861714	861773	861833	861893	861952	862012	862072	60
728	862131	862191	862251	862310	862369	862429	862489	862549	862608	862668	60
729	862728	862787	862847	862906	862966	863025	863085	863144	863204	863263	60
730	863323	863382	863442	863501	863561	863620	863679	863739	863799	863858	59
731	863917	863977	864036	864096	864155	864214	864274	864333	864392	864452	59
732	864511	864570	864629	864689	864748	864808	864867	864926	864985	865045	59
733	865104	865163	865222	865282	865341	865400	865459	865519	865578	865637	59
734	865696	865755	865814	865874	865933	865992	866051	866110	866169	866228	59
735	866187	866346	866405	866465	866524	866583	866642	866701	866759	866819	59
736	866878	866937	866996	867055	867114	867173	867232	867291	867349	867409	59
737	867467	867526	867585	867644	867703	867762	867821	867879	867939	867998	59
738	868056	868115	868174	868233	868292	868350	868409	868468	868527	868586	59
739	868643	868703	868762	868821	868879	868938	868997	869056	869114	869173	59
740	869232	869290	869349	869408	869466	869525	869584	869642	869701	869759	59
741	869818	869877	869935	869994	870053	870111	870169	870228	870287	870345	59
742	870404	870462	870521	870579	870638	870696	870755	870813	870872	870930	58
743	870989	871047	871106	871164	871223	871881	871339	871398	871456	871515	58
744	871573	871631	871689	871748	871806	871865	871923	871981	872039	872098	58
745	872156	872215	872273	872331	872389	872448	872506	872564	872622	872681	58
746	872739	872797	872855	872913	872972	873029	873088	873146	873204	873262	58
747	873321	873379	873437	873495	873553	873611	873669	873727	873785	873844	58
748	873902	873959	874018	874076	874134	874192	874249	874308	874366	874424	58
749	874482	874539	874598	874656	874714	874772	874829	874888	874945	875003	58

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N	0	1	2	3	4	5	6	7	8	9	D
730	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
731	875639	875698	875756	875813	875871	875929	875987	876045	876102	876160	58
732	876218	876276	876333	876391	876449	876507	876564	876622	876679	876737	58
733	876795	876853	876910	876968	877026	877083	877141	877199	877256	877314	58
734	877371	877429	877487	877544	877602	877659	877717	877774	877832	877889	58
735	877947	878004	878062	878119	878177	878234	878292	878349	878407	878464	57
736	878522	878579	878637	878694	878752	878808	878866	878924	878981	879039	57
737	879096	879153	879211	879268	879325	879382	879459	879497	879555	879612	57
738	879669	879726	879784	879841	879898	879955	880013	880070	880127	880185	57
739	880242	880299	880356	880413	880471	880527	880585	880642	880699	880756	57
760	880814	880871	880928	880985	881042	881099	881156	881213	881271	881328	57
761	881385	881442	881499	881556	881613	881669	881727	881784	881841	881898	57
762	881955	882012	882069	882126	882183	882239	882297	882354	882411	882468	57
763	882525	882581	882638	882695	882752	882809	882866	882923	882979	883037	57
764	883093	883050	883207	883264	883321	883377	883434	883491	883548	883605	57
765	883661	883718	883775	883832	883888	883945	884002	884059	884115	884172	57
766	884229	884285	884342	884399	884455	884512	884569	884625	884682	884739	57
767	884795	884852	884909	884965	885022	885078	885135	885192	885248	885305	57
768	885361	885418	885474	885531	885587	885644	885700	885757	885813	885869	57
769	885926	885983	886039	886096	886152	886209	886265	886321	886378	886434	56
770	886491	886547	886604	886659	886716	886773	886829	886885	886941	886998	56
771	887054	887111	887167	887223	887279	887336	887392	887449	887505	887561	56
772	887617	887674	887720	887786	887842	887898	887955	888011	888067	888123	56
773	888179	888236	888292	888348	888404	888460	888516	888573	888629	888685	56
774	888741	888797	888853	888909	888965	889021	889077	889134	889189	889246	56
775	889302	889358	889414	889469	889526	889582	889638	889694	889749	889806	56
776	889862	889918	889974	890029	890086	890141	890197	890253	890309	890365	56
777	890421	890477	890533	890589	890645	890700	890756	890812	890868	890924	56
778	890979	891035	891091	891147	891203	891259	891314	891370	891426	891482	56
779	891537	891593	891649	891705	891760	891816	891872	891928	891983	892039	56
780	892095	892150	892206	892262	892317	892373	892429	892484	892539	892595	56
781	892651	892707	892762	892818	892873	892929	892985	893040	893096	893151	56
782	893207	893262	893318	893373	893429	893484	893539	893595	893651	893706	56
783	893762	893817	893873	893928	893984	894039	894094	894149	894205	894261	55
784	894316	894371	894427	894482	894538	894593	894648	894704	894759	894814	55
785	894869	894925	894980	895036	895091	895146	895201	895257	895312	895367	55
786	895423	895478	895533	895588	895644	895699	895754	895809	895864	895919	55
787	895975	896029	896085	896140	896195	896251	896306	896361	896416	896471	55
788	896526	896581	896636	896692	896747	896802	896857	896912	896967	897022	55
789	897077	897132	897187	897242	897297	897352	897402	897462	897517	897572	55
790	897627	897682	897737	897792	897847	897902	898957	897012	898067	898122	55
791	898176	898231	898286	898341	898396	898451	898506	898561	898615	898670	55
792	898725	898780	898835	898889	898944	898999	899054	899109	899164	899218	55
793	899273	899328	899383	899437	899492	899547	899602	899656	899711	899766	55
794	899821	899875	899929	899985	800039	800094	800149	900203	900258	900312	55
795	900367	900422	900476	900531	900586	900640	900695	900749	900804	900859	55
796	900913	900968	901022	901077	901131	901186	901240	901295	901349	901404	55
797	901458	901513	901567	901622	901676	901731	901785	901839	901894	901948	54
798	902003	902057	902112	902166	902221	902275	902329	902384	902438	902492	54
799	902547	902601	902655	902709	902764	902818	902873	902927	902981	903036	54

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N	0	1	2	3	4	5	6	7	8	9	D
800	903089	903144	903199	903253	903307	903361	903416	903469	903524	903578	54
801	903633	903687	903741	903795	903849	903904	903956	904012	904066	904120	54
802	904174	904229	904283	904337	904391	904445	994499	904553	904607	904661	54
803	904716	904769	904824	904878	904932	904986	905039	905094	905148	905202	54
804	905256	905310	905364	905418	905472	905526	905580	905634	905688	905741	54
805	905796	905849	905904	905958	906012	906066	906119	906173	906227	906281	54
806	906335	906389	906443	906497	906551	906604	906658	906712	906766	906819	54
807	906874	906927	907981	907035	907089	907143	907196	907250	907304	907358	54
808	907411	907465	907519	907573	907626	907680	907734	907787	907841	907895	54
809	907949	908002	908056	908109	908163	908217	908270	908324	908378	908431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
811	909021	909074	909128	909181	909235	909289	909342	909396	909449	909503	54
812	909556	909609	909663	909716	909769	909823	909877	909930	909984	910037	53
813	910091	910144	910197	910251	910304	910358	910411	910464	910518	910571	53
814	910624	910678	910731	910784	910838	910891	910944	910998	911051	911104	53
815	911158	911211	911263	911317	911371	911424	911477	911530	911584	911637	53
816	911690	911743	911797	911849	911903	911956	912009	912063	912116	912169	53
817	912222	912275	912322	912381	912435	912488	912541	912594	912647	912700	53
818	912753	912806	912859	912913	912966	913019	913072	913125	913178	913231	53
819	913284	913337	913389	913443	913496	913549	913602	913655	913708	913761	53
820	913814	913867	913919	913973	914026	914079	914132	914184	914237	914290	53
821	914343	914396	914449	914502	914555	914608	914660	914713	914766	914819	53
822	914872	914925	914977	915030	915083	915136	915189	915241	915294	915347	53
823	915399	915453	915505	915558	915611	915664	915716	915769	915822	915875	53
824	915927	915979	916033	916085	916138	916191	916243	916296	916349	916401	53
825	916454	916507	916559	916612	916664	916717	916769	916822	916875	916927	53
826	916980	917033	917085	917138	917190	917243	917295	917348	917400	917453	53
827	917506	917558	917611	917663	917716	917768	917820	917873	917925	917978	52
828	918030	918083	918135	918188	918240	918293	918345	918397	918449	918502	52
829	918555	918607	918659	918712	918764	918816	918869	918921	918973	919026	52
830	919078	919130	919183	919235	919287	919339	919392	919444	919496	919549	52
831	919601	919653	919706	919758	919810	919862	919914	919967	920019	920071	52
832	920123	920176	920228	920279	920332	920384	920436	920489	920541	920593	52
833	920645	920697	920749	920801	920853	920906	920958	921009	921062	921114	52
834	921166	921218	921270	921322	921374	921426	921478	921530	921582	921634	52
835	921686	921738	921790	921842	921894	921946	921998	922050	922102	922154	52
836	922206	922258	922310	922362	922414	922466	922518	922569	922622	922674	52
837	922725	922777	922829	922881	922933	922985	923037	923089	923140	923192	52
838	923244	923296	923348	923399	923451	923503	923555	923607	923658	923710	52
839	923762	923814	923865	923917	923969	924021	924072	924124	924176	924228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
841	924796	924848	924899	924951	925003	925054	925106	925157	925209	925761	52
842	925312	925364	925415	925467	925518	925569	925621	925673	925725	925776	52
843	925828	925879	925931	925982	926934	926085	926137	926188	926239	926291	51
844	926342	926394	926445	926497	926548	926599	926651	926702	926754	926805	51
845	926857	926908	926959	927011	927062	927114	927165	927216	927268	927319	51
846	927370	927422	927473	927524	927576	927627	927678	927729	927781	927832	51
847	927883	927935	927986	928037	928088	928139	928191	928242	928293	928345	51
848	928396	928447	928498	928549	928601	928652	928703	928754	928805	928857	51
849	928908	928959	929009	929061	929112	929163	929215	929266	929317	929368	51

N	0	1	2	3	4	5	6	7	8	9	D
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
851	929929	929981	930032	930083	930134	930185	930236	930287	930338	930389	51
852	930439	930491	930542	930592	930643	930694	930745	930796	930847	930898	51
853	930949	930999	931051	931102	931153	931204	931254	931305	931356	931407	51
854	931458	931509	931559	931610	931661	931712	931763	931814	931865	931915	51
855	931966	932017	932068	932118	932169	932220	932271	932322	932372	932423	51
856	932474	932524	932575	932626	932677	932727	932778	932829	932874	932930	51
857	932981	933031	933082	933133	933183	933234	933285	933335	933386	933437	51
858	933487	933538	933589	933639	933689	933740	933791	933841	933892	933943	51
859	933993	934044	934094	934145	934195	934246	934296	934347	934397	934448	51
860	934498	934549	934599	934649	934700	934751	934801	934852	934902	934953	50
861	935003	935056	935104	935154	935205	935255	935306	935356	935406	935457	50
862	935507	935558	935608	935658	935709	935759	935809	935859	935910	935960	50
863	936011	936061	936111	936162	936212	936262	936313	936363	936413	936463	50
864	936514	936564	936614	936665	936715	936765	936815	936865	936916	936966	50
865	937016	937066	937117	937167	937217	937267	937317	937367	937418	937468	50
866	937518	937568	937618	937668	937718	937769	937819	937869	937919	937969	50
867	938019	938069	938119	938169	938219	938269	938319	938369	938419	938469	50
868	938519	938569	938619	938669	938719	938769	938819	938869	938919	938969	50
869	939019	939069	939119	939169	939219	939269	939319	939369	939419	939469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
871	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
872	940516	940566	940616	940666	940716	940765	940815	940865	940915	940964	50
873	941014	941064	941114	941163	941213	941263	941313	941362	941412	541462	50
874	941511	941561	941611	947660	941710	941759	941809	941859	941909	941958	50
875	942008	942058	942107	942157	942207	942256	942306	942355	942405	942455	50
876	942504	942554	942603	942653	942702	942752	942801	942851	942901	942950	50
877	942999	943049	943099	943148	943198	943247	943297	943346	943396	943445	49
878	943495	943544	943594	943643	943692	943742	943791	943841	943890	943939	49
879	943989	944038	944088	944137	944186	944236	944285	944335	944384	944433	49
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
881	944976	945025	945074	945124	945173	945222	945272	945321	945370	945419	49
882	945468	945518	945567	945616	945665	945715	945764	945813	945862	945912	49
883	945961	946009	946059	946108	946157	946207	946256	946305	946354	946403	49
884	946452	946501	946551	946599	946649	946698	946747	946796	946845	946894	49
885	946943	946992	947041	947090	947139	947189	947238	947287	947336	947385	49
886	947434	947483	947532	947581	947629	947679	947728	947777	947826	947875	49
887	947924	947973	948022	948070	948119	948168	948217	948266	948315	948364	49
888	948413	948462	948511	948559	948609	948657	948706	948755	948804	948853	49
889	948902	948951	948999	949048	949097	949146	949195	949244	949292	949341	49
890	949390	949439	949488	949536	949585	949633	949683	949731	949780	949829	49
891	949878	949926	949975	950024	950073	950121	950170	950219	950267	950316	49
892	950365	950414	950462	950511	950559	950608	950657	950706	950754	950803	49
893	950851	950900	950949	950997	951046	951095	951143	951192	951240	951289	49
894	951338	951386	951435	951483	951532	951580	951629	951677	951726	951775	49
895	951823	951872	951920	951969	952017	952066	952114	952163	952211	952259	49
896	952308	952356	952405	952453	952502	952550	952599	952647	952696	952744	48
897	952792	952841	952889	952938	952986	953034	953083	953131	953179	953228	48
898	953276	953325	953373	953421	953469	953518	953566	953615	953663	953711	48
899	953759	953808	953856	953905	953953	954001	954049	954098	954146	954194	48

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
901	954725	954773	954821	954869	954918	954966	955014	955062	955110	955158	48
902	955207	955255	955303	955351	955399	955447	955495	955543	955592	955639	48
903	955688	955736	955784	955832	955880	955928	955976	956024	956072	956120	48
904	956168	956216	956265	956313	956361	956409	956457	956505	956553	956601	48
905	956649	956697	956745	956793	956840	956888	956936	956984	957032	957080	48
906	957128	957176	957224	957272	957319	957368	957416	957464	957512	957559	48
907	957607	957655	957703	957751	957799	957847	957894	957942	957990	958038	48
908	958086	958134	958181	958229	958277	958325	958373	958421	958468	958516	48
909	958564	958612	958659	958707	958755	958803	958850	958898	958946	958994	48
910	959041	959089	959137	959185	959232	959279	959328	959375	959423	959471	48
911	959518	959566	959614	959661	959709	959757	959804	959852	959899	959947	48
912	959995	960042	960090	960138	960185	960233	960280	960328	960376	960423	48
913	960471	960518	960566	960613	960661	960709	960756	960804	960851	960895	48
914	960946	960994	961041	961089	961136	961184	961231	961279	961326	961374	47
915	961421	961469	961516	961563	961611	961658	961706	961753	961801	961848	47
916	961895	961943	961990	962038	962085	962132	962179	962227	962275	962322	47
917	962369	962417	962464	962511	962559	962606	962653	962701	962748	962795	47
918	962842	962889	962937	962985	963032	963079	963126	963174	963221	963268	47
919	963315	963363	963410	963457	963504	963552	963599	963646	963693	963741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
921	964259	964307	964354	964401	964448	964495	964542	964589	964637	964684	47
922	964731	964778	964825	964872	964919	964966	965013	965061	965108	965155	47
923	965202	965249	965296	965343	965389	965437	965484	965531	965578	965624	47
924	965672	965719	965766	965813	965859	965906	965954	966001	966048	966095	47
925	966142	966189	966239	966283	966329	966376	966423	966470	966517	966564	47
926	966611	966658	966705	966752	966799	966845	966892	966939	966986	967033	47
927	967079	967127	967173	967220	967267	967314	967361	967408	967454	967501	47
928	967548	967595	967642	967688	967735	967782	967829	967875	967922	967969	47
929	968016	968062	968109	968156	968202	968249	968296	968343	968389	968436	47
930	968483	968529	968576	968623	968669	968716	968763	968809	968856	968902	47
931	968949	968996	969043	969089	969136	969183	969229	969276	969323	969369	47
932	969416	969463	969509	969556	969602	969649	969695	969741	969789	969835	47
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300	47
934	970347	970393	970439	970486	970533	970579	970626	970672	970719	970765	46
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229	46
936	971276	971322	971369	971415	971461	971508	971554	971601	971647	971693	46
937	971739	971786	971832	971875	971925	971971	972018	972064	972110	972157	46
938	972203	972249	972295	972342	972388	972434	972481	972527	972573	972619	46
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082	46
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
941	973589	973636	973682	973728	973774	973820	973866	973913	973959	974005	46
942	974050	974097	974143	974189	974235	974281	974327	974374	974419	974466	46
943	974512	974558	974604	974649	974695	974742	974788	974834	974819	974926	46
944	974972	975018	975064	975109	975156	975202	975248	975294	975339	975386	46
945	975432	975478	975524	975569	975616	975662	975707	975753	975799	975845	46
946	975891	975937	975983	976029	976075	976121	976167	976212	976258	976304	46
947	976349	976396	976442	976488	976533	976579	976625	976671	976717	976763	46
948	976808	976854	976899	976946	976992	977037	977083	977129	977175	977220	46
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	977678	46

N	0	1	2	3	4	5	6	7	8	9	D
950	977724	977769	977815	977861	977906	977952	977998	978042	978089	978135	46
951	978181	978226	978272	978317	978363	978409	978454	978500	978546	978591	46
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	979047	46
953	979093	979138	979184	979229	979275	979321	979366	979412	979457	979503	46
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	979958	46
955	980003	980049	980094	980139	980185	980231	980276	980322	980367	980412	45
956	980458	980503	980549	980594	980639	980685	980730	980776	980821	980867	45
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	981320	45
958	981366	981411	981456	981501	981547	981592	981637	981683	981728	981773	45
959	981819	981864	981909	981954	981999	982045	982090	982135	982181	982226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
961	982723	982769	982814	982859	982904	982949	982994	983039	983085	983129	45
962	983175	983220	983265	983310	983356	983401	983446	983490	983536	983581	45
963	983626	983671	983716	983762	983807	983852	983897	983942	984987	984032	45
964	984077	984122	984167	284212	984257	984302	984347	984392	984437	984482	45
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	984932	45
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	985382	45
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	985830	45
968	985875	985920	985965	986009	986055	986099	986144	986189	986234	986279	45
969	986324	986369	986413	986458	986504	986548	986593	986637	986682	986727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987129	987175	45
971	987219	987264	987309	987353	987398	987443	987488	987532	987577	987622	45
972	987666	987711	987756	987800	987845	987889	987934	987979	988024	988068	45
973	988113	988157	988202	988247	988291	988336	988381	988425	988469	988514	45
974	988559	988604	988648	988693	988737	988782	988826	988871	988916	988960	45
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	989405	45
976	989449	989494	989539	989584	989628	989672	989717	989761	989806	989850	45
977	989895	989939	989983	990028	990072	990117	990161	990206	980250	990294	44
978	990339	990383	990428	990472	990516	990561	990605	990649	990694	990738	44
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	991182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
981	991669	991713	991758	991802	991846	991890	991935	991979	992023	992067	44
982	992111	992156	992199	992244	992288	992333	992377	992421	992465	992509	44
983	992554	992598	992642	992686	992730	992774	992819	992863	992907	992951	44
984	992995	993039	993083	993127	993172	993216	993259	993304	993348	993392	44
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	993833	44
986	993877	993921	993665	994009	994053	994097	994141	994185	994229	994273	44
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	994713	44
988	994756	994801	994845	994889	994933	994977	995021	995065	995108	995152	44
989	995196	995240	995284	995328	995372	995416	995459	995504	995547	995591	44
990	995635	995679	995723	995764	995811	995854	995898	995942	995986	996029	44
991	996074	996117	996161	996205	996249	996293	996337	996380	996424	996468	44
992	996512	996555	996599	996643	996687	996731	996774	996818	996862	996906	44
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	997343	44
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	997779	44
995	997823	997867	997910	997954	997998	998041	998085	998129	998170	998216	44
996	998259	998303	998347	998390	998434	998477	998521	998564	998608	998652	44
997	998695	998739	998783	998826	998869	998913	998956	998999	999043	999087	44
998	999133	999174	999218	999261	999305	999348	999392	999435	999479	999522	44
999	999565	999609	999652	999696	999739	999782	999826	999869	999913	999957	43

A TABLE of PROPORTIONAL PARTS, Whereby the Intermediate Logarithms of all Numbers, and the Numbers of all Logarithms, from 10000 to 100000, may more readily be found out by the foregoing Table of Logarithms.

D	1	2	3	4	5	6	7	8	9	D	1	2	3	4	5	6	7	8	9
43	4	8	12	17	21	25	30	34	38	103	10	20	30	41	51	61	72	82	92
44	4	8	13	17	22	26	30	35	39	104	10	20	31	41	52	62	72	83	93
45	4	9	13	18	22	27	31	36	40	105	10	21	31	42	52	63	73	84	94
46	4	9	13	18	23	27	32	36	41	106	10	21	31	42	53	63	74	84	95
47	4	9	14	18	23	28	32	37	42	107	10	21	32	42	53	64	74	85	96
48	4	9	14	19	24	28	33	38	43	108	10	21	32	43	54	64	75	86	97
49	4	9	14	19	24	29	34	39	44	109	10	21	32	43	54	65	76	87	98
50	5	10	15	20	25	30	35	40	45	110	11	22	33	44	55	66	77	88	99
51	5	10	15	20	25	30	35	40	45	111	11	22	33	44	55	66	77	88	99
52	5	10	15	20	26	31	36	41	46	112	11	22	33	44	56	67	78	89	100
53	5	10	15	21	26	31	37	42	47	113	11	22	33	45	57	67	78	90	101
54	5	10	16	21	27	32	37	43	48	114	11	22	34	45	57	68	79	91	102
55	5	11	16	22	27	33	38	44	49	115	11	23	34	46	57	69	80	92	103
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412	41	82	123	164	206	247	288	329	370
413	41	82	123	165	206	247	289	330	371
414	41	82	124	165	207	248	289	331	372
415	41	83	124	166	207	249	290	332	373
416	41	83	124	166	208	249	291	332	374
417	41	83	125	166	208	250	291	333	375
418	41	83	125	167	209	250	292	334	376
419	41	83	125	167	209	251	293	335	377
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422	42	84	126	168	211	253	295	337	379
423	42	84	126	169	212	253	296	338	380
424	42	84	127	169	212	254	296	339	381
425	42	85	127	170	212	255	297	340	382
426	42	85	127	170	213	255	298	340	383
427	42	85	128	170	213	256	298	341	384
428	42	85	128	171	214	256	299	342	385
429	42	85	128	171	214	257	300	343	386
430	43	86	129	172	215	258	301	344	387
431	43	86	129	172	215	258	301	344	387
432	43	86	129	172	216	259	302	345	388
433	43	86	129	173	216	259	303	346	389
434	43	86	130	173	217	260	304	347	390
435	43	87	130	174	217	261	304	348	391

Some Uses of the following Tables of Logarithms, Sines, *and* Tangents.

AMongst the many admirable ways that have been from time to time invented for propagating the Arts Mathematical, and especially that of Trigonometry, Logarithms, invented by the Lord *Napier*, may challenge the Priority, and the Tables of Artificial Sines and Tangents, composed by Mr. *Gunter*; for that they expedite the Arithmetical Work in most Questions; Multiplication being performed by Addition, and Division by Subtraction, the Square Root extracted by Bipartition, and the Cubique Root by Tripartition: So that by help of these Numbers, and the aforesaid Sines and Tangents, more may be performed in the space of an hour, than by Natural Numbers, or by Vulgar Arithmetick can be in six. Now of what frequent use the Doctrine of Triangles, both Plane and Spherical, is in Astronomy (for the Resolution of which the Tables following chiefly serve) let the preceeded Work testify. And therefore I think it not amiss here in this place to insert some few Propositions, to shew the Use of the Tables of Logarithms and of Sines and Tangents following.

PROB. I. *How to find the Logarithms of any Number under* 1000.

EVery Page in the Table of Logarithms is divided into 11 Columns; in the first of which Columnns, having the Letter N at the Head thereof, are all Numbers successively continued from 1 to 1000: So that to find the Logarithms of any Number, is no more but to find the Number in the *1st* Column, and in the *2d* Column you shall have the Logarithm answering thereunto.

Example. Let the Number given be 415, and if it is required to find the Logarithm thereof, in the Table of Logarithms, in the first Column thereof, under the Letter N, I find the Number 415, and right against it in the next Column I find *6*18048, which is the Logarithm of 415. In the same manner you may find the Logarithm of any Number under 1000; as the Logarithm of 506 is 704151, and the Logarithm of 900 is 954243, *&c.*

But here is to be noted, That before every Logarithm must be placed his proper Characteristick; *viz.* If the Number consist but of one Figure, as all Numbers under 10, then the Characteristick is 0; if the Number consist of two Figures, as all Numbers between 10 and 100, then the Characteristick is 1; if the Number consist of three Figures, as all Numbers between 100 and 1000, then the Characteristick is 2; and if the Number consists of four Figures, as all between 1000 and 10000, the Characteristick must be three. In brief, the Characteristick of any Logarithms must consist of an Unit less than the given Number hath places: And by observing this Rule, the Logarithm of 415 will be 2.618048, and the Logarithm of 506 is 2.704151, and the Logarithm of 900 is 2.954243, *&c.*

PROB. II. *A Logarithm being given, to find the Absolute Number thereunto belonging, by the former Observation; the Characteristick will declare of what Number of Places the Absolute Number consists:*

LEt the Logarithm given be 2.164353; now because the Characteristick is 2, I know by it the Absolute Number consisteth of three places, and therefore may be found in the second Column of the Logarithm Tables, against it I find 146, which is the Absolute Number answering to the Logarithm of 2.164353.

PROB. III. *How to find the Logarithm of a Number that consisteth of four Places.*

YOu must find the three first Figures of the given Number in the first Column, as before, and seek the last Figure thereof amongst the great Figures in the head of the Page; and in the common Area or meeting of these two Lines is the Logarithm you desire, if before it you add or prefix its proper Characteristick.

Example. Let it be required to find the Logarithm of 5745; I find 574, the three first Figures, in the first Column, and 5, the last Figure in the head of the Table; then going down from 5 in the head of the Table, until I come against 574 in the first Column, there I find 759290, before which I place 3 for the Characteristick, and it makes 3.759290, and that is the Logarithm sought for.

PROB.

PROB. IV. *Any Number of Degrees and Minutes being given, to find the Artificial Sine and Tangent thereof.*

ADmit it were required to find the Sine of 21 deg. 24 min. I turn to the Sines in the Table, and in the head thereof I find deg. 21; then in the first Column (under M) I find 24, and right against it is 9.562146 for the Sine, and 9.593170 for the Tangent of 21 deg. 24 min. But suppose it were required to find the Sine or Tangent of 56 deg. 35 min. Note, all under 45 deg. are found in the head, and the odd min. in the left hand; and all above 45 deg. are found in the foot of the Table, and the min. last Column towards the right hand; as in this Example the Sine of 56 deg. 35 min. is 9.921524, and the Tangent is 10.180590.

PROB. V. *If any Sine or Tangent be given, to find what Degrees and Minutes answer thereunto.*

SUppose 9.584663 were a Sine given, I look for the Number in the Table of Sines and and I find it stand against 22 deg. 36 min. and therefore is the Sine thereof. As admit 9.624330 were a Tangent given, look for the Number in the Column of Tangents, and I find stand aginst it 22 deg. 50 min. The same must be done for any other.

The Use of the Table of Proportion, for the more ready finding out of any Logarithm, from 10000 to 100000.

WHen you have any Logarithm or Number above 10000, you may find it by the differences which are in the last Column of the Tables: and for your more easy and ready performing it, this Table is framed; wherein you have the proportional Differences: So that between each of the 10000 Logarithms in the Table, you may easily know the ten Intermediate Logarithms, by the Proportional Part of the Difference for any of them.

Thus in the Table the Logarithm of 2000 is 3.301030
The next Logarithm, being the Logarithm of 2001, is 3.301247

Alter the Characterick of these Logarithms,

So have you the Logarithm of 20000, 4.301030
And the Logarithm of 20010, 4.301247

The Difference between these two Numbers is 217, which for the ten Intermediate Logarithms must be divided into 10 proportional parts, which is ready done in this Table, as follows.

D	1	2	3	4	5	6	7	8	9
217	21	43	65	86	108	130	151	173	195

So that the Logarithm of 20000 being 4.301030
The Logarithm of 20001, by adding 21, is 4.301051
The Logarithm of 20002, by adding 43, is 4.301073
And so for the rest, to 20010.

Or, on the other side, let your Logarithm given be 4.301051, and you desire to know what Number answers to it; the next Number less in the Tables is 301030 which is the Logarithm of 20000: but this is 21 more, and the common Difference in the Table is about 217; turn therefore to this Difference in the Table of Proportion, and there you shall see that 21 makes your number 1 more: So that 4.301051 is the Logarithm of 20001.

FINIS.